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DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Md. 20084

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A LIFTING LINE COMPUTER PROGRAM FOR PRELIMINARY DESIGN OF PROPELLERS

by

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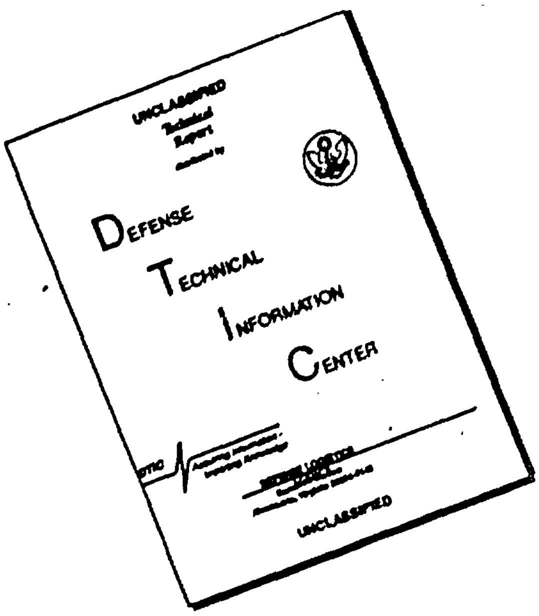

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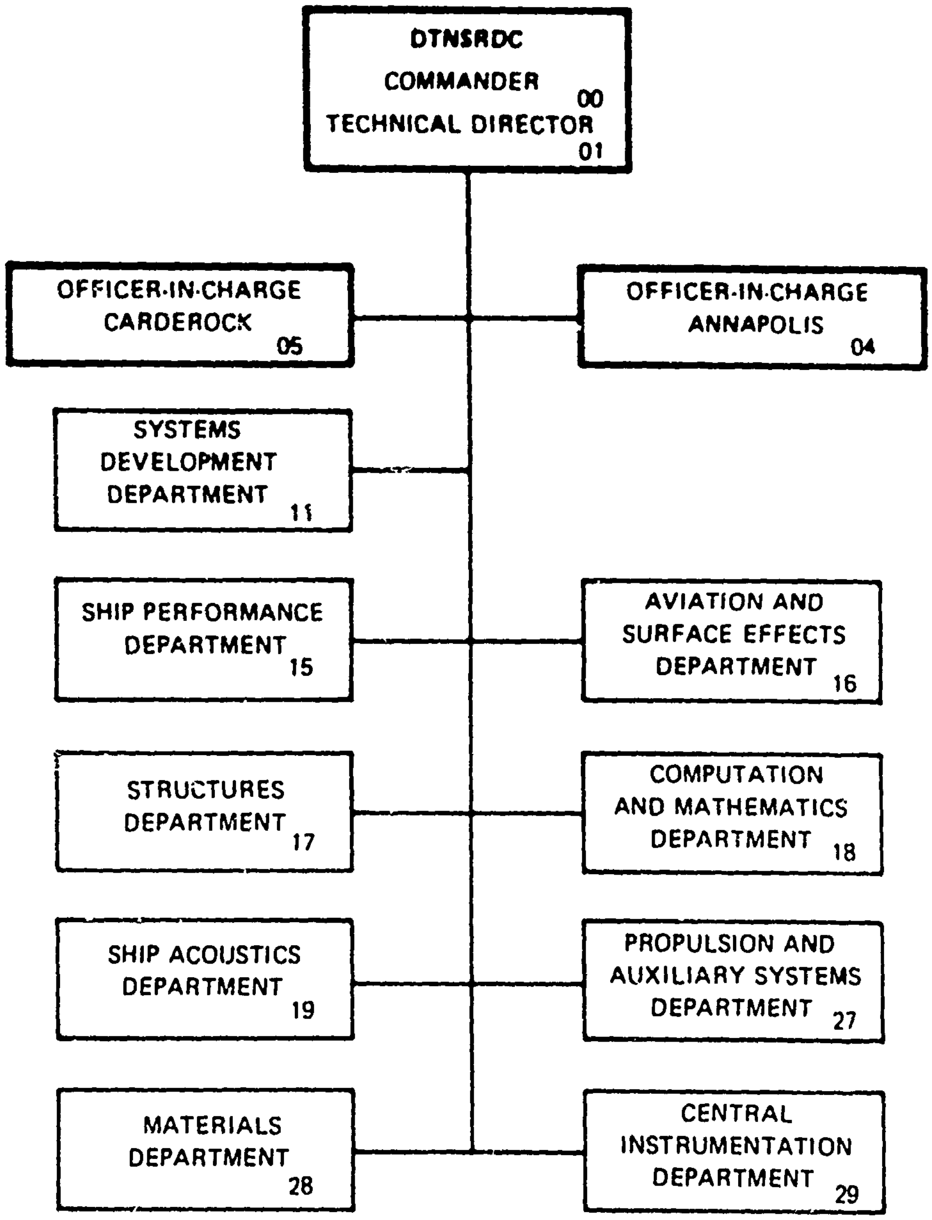

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This report presents a computer program that can be used for the preliminary design and to predict the performance of single screw propellers when designed for a prescribed hydrodynamic pitch distribution. This design program is based on lifting line theory as developed by Lerbs for moderately-loaded finite-bladed propellers. Stress calculations using beam theory are also made for each design, which take into account the effect of blade skew and rake. Design

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calculations can be made for given design speeds where delivered shaft power is computed (Thrust Option), or for the case when the delivered shaft power is specified and the corresponding speed is computed (Power Option). A FORTRAN listing of the program, developed to run on the computers at the David W. Taylor Naval Ship Research and Development Center (DTNSRDC), is presented as well as input and output obtained for two sample designs, one using the Thrust Option, and the other the Power Option.

NTIS White Section
Buff Section
Dist
A

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NOTATION

A_E	Expanded blade area, $Z\int_{r_h}^{R} c\, dr$
A_E/A_0	Propeller expanded area ratio, $(2Z/\pi)\int_{x_h}^{1} (c/D)\, dx$
$(A_E/A_0)_k$	Keller's minimum expanded area ratio for eliminating back bubble cavitation, $(2.6+0.6Z)K_T/\{\sigma_{0.7}[J^2+(0.7\pi)^2]\}+K$
A_0	Disc area, $\pi D^2/4$
A_P	Estimated propeller projected area, $[1.067-0.229\ (P/D)_i]A_E$
$a(x)$	Area of section, $2c(x)t(x)\int_0^1 t(x,x_\ell)dx$
$B(x)$	Distance of CG from hub face, $\bar{y}\cos\phi + \bar{x}\sin(\phi-\theta_S)\ x\ R\tan(\phi-\theta_R)\ x+D_H/2$
$(c/R)_{LE}$, $(c/R)_{TE}$	Chord lengths measured from leading edge and trailing edge of blade to propeller reference line
C_D	Section drag coefficient
C_{FO}	Frictional resistance of section
CG	Center of gravity
C_L	Blade section lift coefficient
C_P	Power loading coefficient, $P_D/[(\rho/2)\pi R^2 V_A{}^3]$
C_{PS}	Power loading coefficient based on ship speed, $P_D/[(\rho/2)\pi R^2 V^3]$; calculated $\int_{x_h}^{1}(1+\epsilon/\tan\beta_I)$ $(dC_{PSi}/dx)\, dx$
C_{Th}	Thrust loading coefficient, $T/[(\rho/2)\pi R^2 V_A{}^2]$
C_{TS}	Thrust loading coefficient based on ship speed, $T/[(\rho/2)\pi R^2 V^2]$; calculated $\int_{x_h}^{1}(1-\epsilon\tan\beta_I)$ $(dC_{TSi}/dx)\, dx$
C_{ThP}	Power loading coefficient, $\int_{x_h}^{1}(1-w_x)(1-\epsilon\tan\beta_I)$ $(dC_{TSi}/dx)\, dx$
c	Propeller blade chord length, $c(x)$

C_{PSi}	Inviscid power loading coefficient, $(4Z/\lambda_s)xG[(1-w_x)+U_T/2V]$
C_{TSi}	Inviscid thrust loading coefficient, $4ZG[(x/\lambda_s)-U_A/2V]$
D	Propeller diameter
D_h	Hub diameter
$F(x)$	Parameter for calculating the fluctuating angles of attack, $1/[1+2\pi\tan(\beta_i-\beta)/C_L]$
f_M	Camber
g	Acceleration due to gravity
G(r)	Nondimensional circulation about a blade section $\Gamma/(2\pi RV)$
G_F	Spacing between fillets
G_Z	Spacing between blades at the hub
H	Static head at propeller shaft centerline
I_{xo},I_{yo}	Moment of inertia of blade section about x and y axes
J	Advance coefficient, $V(1-w_T)/(nD)=V_A/(nD)$
J_V	Ship speed advance coefficient, $V/(nD)$
K	Kellers' constant for predicting minimum blade area of propeller (see p. 22)
K_Q	Torque coefficient, $Q/(\rho n^2 D^5)$
K_T	Thrust coefficient, $T/(\rho n^2 D^4)$
L_I	Propeller lift distribution per unit span for finite element stress calculations
M_p	Moment of blades, see page 34

M_{Tb}, M_{Qb}	Moment due to thrust and torque
M_{xo}, M_{yo}	Moment parallel and perpendicular to the nose - tail line
n	Propeller revolution per unit time
$(P/D)_i$	Estimated propeller pitch ratio at 0.7 radius, $0.7\pi \tan\beta_I$ in program
P_D	Delivered power at propeller, $2\pi Qn$
P_E	Effective power
P_S	Shaft power
Q	Propeller torque
R	Propeller tip radius
rpm	Propeller revolutions per minute
r	Propeller local radius
r_h	Propeller hub radius
r_ℓ	Local position along the section chord
T	Propeller thrust
t	Propeller blade maximum thickness $t(x)$, thrust deduction fraction
$t(x, x_\ell)$	Chordwise distribution of section thickness (NACA 66 modified thickness form is used)
$U_A/2V$	Axial induced velocity at lifting line
$U_T/2V$	Tangential induced velocity at lifting line
V	Ship speed
V_A	Speed of advance of the propeller, $V(1-w_T)$

V_X	Local velocity along the x axis at any field point
V_r	Inflow velocity at each propeller section, $V\sqrt{[(1-w_x)+U_A/2V]^2+[X/\lambda_s-U_T/2V]^2}$
w_a/V	Axial velocity from sources other than the propeller wake $(1-w_x)$
W_B	Weight of blades
W_H	Weight of hub
W_P	Propeller weight
w_c	Circumferential mean wake fraction at each radius calculated from wake survey
w_t/V	Tangential velocity from sources other than the propeller wake $(1-w_x)$
w_T	Propeller effective wake fraction as determined from thrust identity from self propulsion experiment
w_v	Volume mean wake fraction
w_x	Propeller wake fraction, $1-[(1-w_T)/(1-w_v)](1-w_c)$
x	Nondimensional radial distance, r/R
x_h	Nondimensional hub radius, r_h/R
x_ℓ	Nondimensional distance along section chord, r_ℓ/c
Z	Number of blades
Z_R	Propeller rake
Z_T	Total rake, rake plus skew induced rake

α_i	Section ideal angle of attack, $1.54C_L$ for NACA a=0.8 meanline in two dimensional flow
α_{max}	Maximum fluctuating angle of attack, $\alpha_i-(-\Delta\beta)F(x)$
α_{min}	Minimum fluctuating angle of attack, $\alpha_i-(+\Delta\beta)F(x)$
β	Advance angle of a propeller blade section
β_I	Hydrodynamic flow angle of a propeller blade section
Γ	Circulation about a propeller blade section,
ε	Section drag-lift ratio, C_D/C_L
η_D	Propulsive efficiency, $P_E/P_D=(1-t)C_{TS}/C_{PS}$
η_{Pe}	Estimated propeller efficiency, C_{THP}/C_{PS}
θ_R	Blade rake angle in degrees
θ_S	Blade skew angle in degrees
λ_S	Advance ratio of propeller based on ship speed, $V/(\pi nD)$
ρ	Water density
ρ_p	Density of propeller material
ϕ	Pitch angle
σ	Section cavitation number, $2gH/V_r^2$
$\sigma_{0.7}$	Burrill cavitation number, $2gH/[\{V(1-w_{x=0.7})\}^2+\{0.7\pi nD\}^2]$
τ_c	Burrill thrust loading coefficient, $T/[\{V(1-w_{x=0.7})\}^2+\{0.7\pi nD\}^2]$

ABSTRACT

This report presents a computer program that can be used for the preliminary design and to predict the performance of single screw propellers when designed for a prescribed hydrodynamic pitch distribution. This design program is based on lifting line theory as developed by Lerbs for moderately-loaded finite-bladed propellers. Stress calculations using beam theory, propeller weight, moments of inertia, and center of gravity for specified hubs are also made for each design, which take into account the effect of blade skew and rake. Design calculations can be made for given design speeds where the corresponding shaft power is computed (thrust option), or for the case when the shaft power is specified and the corresponding speed is computed (power option). A FORTRAN listing of the program, developed to run on the computers at the David W. Taylor Naval Ship Research and Development Center (DTNSRDC) is presented as well as the input and output obtained for two sample designs, one using the thrust option, and the other the power option.

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INTRODUCTION

The David W. Taylor Naval Ship Research and Development Center (DTNSRDC), Carderock Laboratory, was requested by the Naval Ship Systems Command (NAVSHIPS) to develop a computer program that can be used as an aid in determining optimum values of propeller design parameters such as diameter, rpm, and blade number for naval vessels. This report has the objective of presenting a computer program that can be easily used for the preliminary design and for prediction of the performance of propellers applicable to specific ships.

The main portion of the computer program makes preliminary propeller design calculations and performance predictions using Lerbs' lifting line moderately-loaded finite-bladed propeller theory of References 1 and 2. Once the lifting

1. Lerbs, H.W., "Moderately Loaded Propellers with a Finite Number of Blades and an Arbitrary Distribution of Circulation," Transactions of the Society of Naval Architects and Marine Engineers, Vol. 60, p 73-117, 1952
2. Morgan, W.B. and Wrench, J.W., Jr., "Some Computational Aspects of Propeller Design," Methods in Computational Physics, Vol. 4, Academic Press Inc., New York, p 301-331, 1965

line calculations for the propeller have been obtained, a computer program based on lifting surface theory must be used to determine the final pitch and camber of the propeller[3]. Numerous experimental checks[4] on the design procedure used have verified this procedure.

A computer program for the preliminary design of propellers having a prescribed pitch or circulation distribution was previously published in Reference 5. One of the most important new features of the new computer program is the power option which computes the speed automatically when the design power is specified. Other features included in the present computer program follows:

1. Only one set of basic input data is required for the preliminary design of a series of propellers with rpm, blade number and expanded area ratio varied. Any number of basic sets of data can be specified in the computer program.

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3. Morgan W.B., Silovic, Vladimir and Denny, Stephen B., "Propeller Lifting-Surface Corrections," Transactions of the Society of Naval Architects and Marine Engineers, Vol. 76, p 309-347, 1968
4. Boswell, R.J., "Design, Cavitation Performance and Open-Water Performance of a Series of Research Skewed Propellers," Naval Ship Research and Develpment Center Report 3339, March 1971
5. Haskins, E.W., "Calculations of Design Data for Moderately Loaded Marine Propellers by Means of Induction Factors," Naval Ship Research and Development Center Report 2380, September 1967

2. The propeller stress, based on beam theory[6], modified to account for the effect of rake and skew, is computed for each design. An input option is used to make stress calculations for a linear or nonlinear distribution of blade skew.

3. Parameters required to make blade surface cavitation checks using the Burrill cavitation charts of Reference 7 and Brockett's incipient cavitation diagrams of Reference 8 are calculated on the computer. In addition, Keller's method[9] of predicting the minimum expanded area ratio based on back bubble type cavitation, is calculated. The estimated propeller weight including the hub, and input parameters required for the lifting surface computer program used to calculate the final pitch and camber of propeller designs are some of the other parameters calculated.

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6. Eckhart, M.K. and Morgan, W.B., "A Propeller Design Method," Transactions of the Society of Naval Architects and Marine Engineers, Vol. 63, p 305-370, 1955
7. Burrill, L.C. and Emerson, A., "Propeller Cavitation: Further Tests on 16 Inch Propeller Models in the Kings College Cavitation Tunnel," Transactions of the North East Coast Institution of Engineers and Ship Builders, Vol. 78, p 295-320, 1963-64
8. Brockett, Terry, "Minimum Pressure Envelopes for Modified NACA-66 Sections with NACA a=0.8 Camber and BUSHIPS Type I and Type II, Sections," David Taylor Model Basin Report 1780, 1966
9. Keller, J. Auf'm, "Enige aspectem bij het ontwerpen van Scheepsschroeven," Schip en Werk, No. 24, p 658-662, 1966

PROPELLER LIFTING LINE THEORY

The availability of high speed digital computers has made it now possible to make use of more adequate mathematical models to represent the hydrodynamic action of marine propellers. The computer has also released the designer from performing laborious computations involved in present design methods.

The lifting line theory used in the computer program presented here is the theory developed by Lerbs (Reference 1) for moderately-loaded finite-bladed propellers. This lifting line design method discussed by Cox and Morgan in Reference 10 also permits the designer to accurately account for propeller parameters such as number of blades, hub size, radial blade-loading, and wake distribution. Since this theory is discussed in detail in References 1 and 2, only some of the assumptions made in developing the theory are mentioned here. The theory developed by Lerbs' considers the influence of the induced velocities on the shape of the helical vortex sheet at the lifting line, but neglects the effect of centrifugal forces and the contraction of the slip-stream. In addition, the change in shape of the vortex lines is neglected in the axial direction, indicating that each vortex line is assumed to be of constant pitch. However, the vortex sheets are not necessarily helical surfaces since the pitch may vary along the radius.

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10. Cox, G.G. and Morgan, W.B., "The Use of Theory in Propeller Design," Marine Technology, Vol. 9, No. 4, p 419-429, October 1972

The computer program can be used for the preliminary design of a propeller having a prescribed pitch distribution. The viscous effects of the propeller are taken into account by giving as input the blade-section drag coefficient and chord lengths. Blade stresses are computed using simple beam theory by giving as additional input the blade thickness, rake, and skew.

DESCRIPTION OF INPUT DATA

Dimensioned parameters may be input in the appropriate S.I. or English units, as specified by the user illustrated in Table 1. Effective power, shaft power, speed (V), number of blades (Z), diameter (D), rpm, propeller wake ($1-w_x$), and estimate of the hydrodynamic flow angle distribution (β_I) are required input parameters in order to make nonviscous propeller design calculation [1,2]. The radial distribution of blade chord lengths nondimensionalized on diameter (c/D) and section drag coefficients (C_D) must also be specified as input if design calculations are to account for the propeller viscous effects. Since the computer program presented calculates the propeller principal stresses based on beam theory, the radial distribution of maximum thickness nondimensionalized on chord length (t/c), rake nondimensionalized on diameter (Z_R/D), and skew angle (θ_S) must also be input parameters. The blade section cavitation number (σ) is a required parameter in order to make blade surface cavitation checks using the Burrill cavitation diagrams of Reference 7 and Brockett's incipient cavitation

diagrams of Reference 8. By specifying the static head (H) as input data, the cavitation number (σ) is calculated on the computer. Hub dimensions can be input or assumed to be a circular cylinder of equal length and diameter as described in Appendix A. A brief description of how these input parameters can be determined will be discussed in this section.

Effective Power, Speed, and Shaft Power

Effective power and speed are normally obtained from model self-propulsion experiments. Input effective power (P_E) and shaft power (P_S) are defined as follows:

$$P_E = VT(1-t)$$

$$P_S = 2\pi nQ$$

where n = propeller revolutions

P_S = shaft power,

P_E = effective power,

Q = propeller torque,

T = propeller thrust,

V = ship speed

(1-t) = thrust deduction, which may vary with diameter and speed.

Nondimensional Radial Distance (X)

This is a reference set of eleven nondimensional radial distances x_i at which all other distributions, either input or calculated by the computer, are defined as existing. In general $x_i = r_i/R$, with the restrictions

$x_1 = r_h/R$

$x_{11} = R/R=1$,

where r_i = the distance along the propeller reference line from the shaft axis to the ith section,

r_h = propeller hub radius, and

R = propeller tip radius.

Propeller Wake

The radial distribution of the axial wake $(1-w_x)$ which varies with propeller diameter is also required input data. The circumferential mean of the axial velocity distribution $(1-w_c)$ is obtained from a wake survey without the propeller operating. However, the $(1-w_c)$ wake distribution must be corrected for the propeller action. No completely satisfactory method is presently available to obtain this correction, but an approximation of the radial distribution of the wake $(1-w_x)$ with the propeller operating is obtained as follows:

Wake distribution

$$(1-w_x) = [(1-w_T)(1-w_c)]/(1-w_v) \quad [1]$$

where $(1-w_c)$ = radial distribution of the circumferential mean wake from wake survey data,

$(1-w_T)$ = effective wake from self propulsion data

$(1-w_v)$ = volume mean wake, $[2/(1-x_h^2)]\int_{x_h}^{1}(1-w_c)\, x dx$,

R = propeller radius,

r = propeller local radius

r_h = propeller hub radius,

x = nondimensional radial distance (r/R), and

x_h = nondimensional hub radius (r_h/R).

The propeller wake distribution may also vary with propeller diameter depending on the hull characteristics of the vessel.

Advance Angle Distribution Input Option

The advance angle distribution ($\tan\beta$) is normally calculated from the equation $V(1-w_x)/(\pi nDx)$ using the propeller wake $(1-w_x)$ from Equation [1]. For most single screw propeller designs this approach gives good performance predictions. In a few instances, it may be desired to utilize the computer program presented to design and predict the performance of propellers operating inside a duct or in the vicinity of another propeller as in the case of tandem or contrarotating propellers where the axial (w_a/V) and

tangential (w_t/V) velocities induced by these additional sources near the propeller plane can be predicted. In this case, an option in the computer program allows the input of the estimated $\tan\beta$ distribution which accounts for the axial (w_a/V) and tangential (w_t/V) velocities induced by other sources in the following manner:

Equation for Estimating $\tan\beta$ If Input Option Is Used

$$\tan\beta_{estimated} = [(1-w_x) + w_a/V)]/[(x/\lambda_s)-(w_t/V)] \qquad [2]$$

where w_a/V = axial velocity from other sources,

w_t/V = tangential velocity from other sources,

λ_s = advance ratio based on ship speed, $V/(\pi nD)$,

V = ship speed, and

D = propeller diameter.

It can be seen from Equation [2] that for the case where (w_a/V) and (w_t/V) values are specified as zero, the advance angle $\tan\beta$ is calculated in the usual manner when designing single screw propellers. If the $\tan\beta$ input option is used, the $\tan\beta$ values are calculated using Equation [2]. For the normal single screw propeller design case, $\tan\beta$ is calculated on the computer.

Hydrodynamic Flow Angle Distribution

The hydrodynamic flow angle distribution ($\tan\beta_I$) can be specified as input. An option is included so Lerb's optimum

$\tan\beta_I$ distribution[6] can be calculated by the computer as follows:

$$\tan\beta_I = (\tan\beta/\eta_i)[(1-w_T)/(1-w_x)]^{1/2} \qquad [3]$$

where η_i = propeller ideal efficiency

η_i = 0.85 is used in the program, and

$\tan\beta$ = advance angle distribution

Lerbs' optimum $\tan\beta_I$ distribution usually results in optimum propeller efficiency. If other factors such as cavitation, strength and vibration are considered, the input of an alternate $\tan\beta_I$ distribution may be desired.

Static Head

The static head (H) at the shaft centerline is required input. This parameter (H) is defined as $H_s+H_a-H_v$, where H_s is the shaft submergence, H_a is the atmospheric pressure, and H_v is the vapor pressure of fluid which is normally small compared with H_a and may be neglected. The static head (H) is used to calculate the section cavitation number (σ) in Equation [25] and the Burrill cavitation number $\sigma_{0.7}$ of Equation [30].

Blade Outline and Expanded Area Ratio

The blade outline (c/D) and expanded area ratio (A_E/A_0) must be input for the design. An expanded area ratio (A_E/A_0) is calculated on the computer according to:

$$A_E/A_0 = (2Z/\pi)\int_{x_h}^{1} c/D \, dx$$

where c/D = nondimensional chord length, and

Z = number of blades

If the (A_E/A_0) input value differs from the one indicated in equation [4], adjusted (c/D) values used for the design are calculated as follows:

$$(c/D)_{adj} = (c/D)_{input} (A_E/A_0)_{calc} / (A_E/A_0)_{design}$$

The final blade outline and expanded area ratio should be chosen to give satisfactory propeller strength and cavitation characteristics.

Blade Thickness to Chord Ratio

The input of maximum thickness to chord ratio (t/c) values allow an estimate of the propeller principal stresses (see The Propeller Stress Calculations Using Beam Theory section discussed later) based on beam theory[6] to be calculated during the preliminary design stage of the propellers. From a rough estimate of the blade outline (c/D) for the final design and an estimate of the radial distribution of thickness (t/D) based on fatigue strength[6], the following equation can be used to obtain initial (t/c) input values:

Blade Thickness Ratio:

$$t/c = (t/D)/(c/D)$$

where t/D = radial distribution of thickness (can be estimated from Reference 6).

Rake and Skew

Nondimensional rake (Z_R/D) and the skew angles (θ_S) for a design are specified to permit adequate predictions of principal propeller stresses using the beam theory method described in Reference 6 and discussed later in the propeller stress section of this report.

The rake (Z_R) is defined consistent with Reference 11 (see Figures 1 through 2d) as the distance from the propeller plane to the generator line in the direction of the shaft axis. Aft displacement is considered positive rake (see Figures 2a).

Since the skew angles (θ_S) significantly affect propeller unsteady forces, a computer program based on the unsteady propeller lifting surface theory of References 12, 13, 14, and 15 can be used to select the skew angles (θ_S) for the propeller design. The input skew angles (θ_S) in degrees are defined as the angular displacement of points on the blade reference line from the propeller reference line in the projected view.

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11. Cumming, R.A., Dictionary of Ship Hydrodynamics - Propeller Section, 14th International Towing Tank Conference 1975, Report of Presentation Committee, Appendix VII
12. Tsakonas, S., Breslin, J., and Miller, M., "Correlation and Application of an Unsteady Flow Theory for Propeller Forces," Transactions of the Society of Naval Architects and Marine Engineers, Vol. 75, p 158-193, 1967
13. Breslin, J.P., "Exciting-Force Operators for Ship Propellers," Journal of Hydronautics, Vol. 5, No. 3, p 85-90, July 1971
14. Jacobs, W.K., Mercier, J., and Tsakonas, S., "Theory and Measurements of the Propeller-Induced Vibratory Field," Davidson Laboratory Report SIT-DL-1485, December 1970
15. Tsakonas, S., Jacobs, W.R., and Ali, M.R., "An Exact Linear Lifting Surface Theory for Marine Propeller in a Nonuniform Flow Field," Journal of Ship Research, Vol. 17, No. 4, December 1974

Section Drag Coefficient

In order to account for viscous effects when predicting the performance of a propeller, the section drag coefficient (C_D) must be specified as input. A section drag coefficient (C_D) value of 0.0085 usually gives reasonable estimates of model propeller drag for propeller shapes normally used at DTNSRDC in the past. For propellers having very thick blades, the following equation, available as an input option on the computer, and derived as a function of maximum thickness (t/c) values using experimental data from NACA 66 type sections,[16,17] will give a better estimate of the section drag coefficient (C_D):

Section Drag Coefficient:

$$C_D = C_{FO} \, [1+1.25(t/c)+125 \, (t/c)^4]$$

where C_{FO} is the friction resistance of the section, e.g., $C_{FO} \approx 0.008$ for Reynolds number of approximately 10^6 and $C_{FO} \approx 0.004$ for Reynolds numbers of approximately 10^8.

Options for using alternate nonlinear C_D distributions, or a constant C_D distributions are also available.

Final Pitch Ratio (P/D) Input Option

The final pitch-diameter ratio (P/D) distribution defined as $\pi x \tan \phi$ where ϕ is the pitch angle is normally not known during the preliminary design stage of the propeller. Because of this hydrodynamic flow angle (β_I) from lifting line

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16. Abbot, Ira H. and Von Doenhoff, Albert E., "Theory of Wing Sections Including a Summary of Airfoil Data," Dover Publications Inc., New York, Library of Congress Catalog No. 60-1601, 1949.

17. Hoerner, S.F., "Fluid-Dynamic Drag," Published by the author, Midland Park, New Jersey, 1965.

calculations is substituted for the pitch angle (ϕ) in the bending moment calculations when making stress calculations using beam theory and when predicting clearance between blades and fillets at the propeller hub. If the final P/D values are known, they can be used.

DESIGN AND PROPULSIVE PERFORMANCE PARAMETERS CALCULATED

In order to simplify propeller design calculation procedures, the design thrust and power of propellers are usually considered in nondimensional form. The nondimensional design thrust loading coefficients (C_{TS} and C_{Th}) and design power loading coefficients (C_{PS} and C_p) are calculated on the computer in the following manner:

Thrust Loading Coefficients:

$$C_{TS} = T/[(\rho/2)]\pi R^2 V^2 \text{ or } C_{Th} = T/[(\rho/2)\pi R^2 V_A{}^2 \qquad [7]$$

Power Loading Coefficients:

$$C_{PS} = P_D/[(\rho/2)\pi R^2 V^3] \text{ or } C_P = P_D/[(\rho/2)\pi P^2 V_A{}^3] \qquad [8]$$

where V = ship speed,

V_A = speed of advance of propeller, $V(1-w_T)$, and

ρ = density of fluid

Lerbs lifting line theory is used to determine the propeller lift coefficient (C_L), circulation (G), hydrodynamic flow angle (β_I), axial induced velocity ($U_A/2V$), and

tangential induced velocity ($U_T/2V$). These lifting line calculations take into account propeller viscous effects by specifying as input in the computer program the propeller section nondimensional chord length (c/D) and section drag coefficient (C_D). A method for obtaining values for c/D and C_D is discussed in the Description of Input Data section of the report. Design parameters such as thrust loading coefficient (C_{TS}), thrust power coefficient (C_{ThP}), power loading coefficient (C_{PS}), propeller efficiency (η_P), and propulsive efficiency (η_D) are calculated for each propeller in the following manner:

Thrust Loading Coefficient:

$$C_{TS}=\int_{x_h}^{1} (1-\varepsilon\tan\beta_I)(dC_{TSi}/dx)dx=T/[(\rho/2)\pi R^2V^2] \qquad [9]$$

Thrust Power Coefficient:

$$C_{ThP}=\int_{x_h}^{1}(1-w_x)(1-\varepsilon\tan\beta_I)(dC_{TSi}/dx)dx=(1-w_T)\{T/[(\rho/2)\pi R^2V^2]\} \qquad [10]$$

Power Loading Coefficient:

$$C_{PSe}=\int_{x_h}^{1}(1+\varepsilon/\tan\beta)dC_{PSi}/dx)dx=P_S/[(\rho/2)\pi R^2V^3] \qquad [11]$$

Estimated Propeller Efficiency:

$$\eta_{Pe}= C_{ThP}/C_{PS} \simeq TV_A/(2\pi Qn) \qquad [12]$$

Estimated Propulsive Efficiency:

$$\eta_D=(1-t)C_{TS}/C_{PS}=P_E/P_D \qquad [13]$$

where C_L = section lift coefficient from lifting line theory

C_{TSi} = nondimensional inviscid local thrust loading coefficient, $4ZG\left[x/\lambda_S - U_T/2V\right]$

C_{PSi} = nondimensional inviscid local power loading coefficient, $(4Z/\lambda_S)xG[(1-w_x)+U_T/2V]$

G = nondimensional circulation from lifting line theory

$U_A/2V$ = axial induced velocity from lifting line theory

$U_T/2V$ = tangential induced velocity from lifting line theory

The calculated propeller thrust (T) is obtained by substituting the C_{TS} calculated in Equation [9] into Equation [7] and the delivered power P_D is obtained by substituting C_{PS} computed using Equation [11] into Equation [8].

Other parameters useful in designing and evaluating the performance of propellers include the advance coefficient (J), ship speed advance coefficient (J_V), thrust coefficient (K_T), torque coefficient (K_Q), moment due to thrust (M_{Tb}), moment due to torque (M_{Qb}), moment parallel to section nose-tail line (M_{xo}), moment perpendicular to the nose-tail line (M_{yo}) and the blade loading distribution (L J). These parameters are calculated as follows:

Advance Coefficient:

$$J=V(1-w_T)/(nD)=V_A/(nD) \qquad [14]$$

Ship Speed Advance Coefficient:

$$J_V = V/(nD) \qquad [15]$$

Thrust Coefficient:

$$K_T = T/(\rho n^2 D^4) = (\pi C_{TS}/8) J_V^2 \qquad [16]$$

Torque Coefficient:

$$K_Q = Q/(\rho n^2 D^5) = (C_{PS}/16) J_V^3 \qquad [17]$$

Moment Due to Thrust:

$$M_{Tb}(x_o) = [\rho \pi R^3 V^2/(2Z)] \int_{x_h}^{1} (x - x_o)(1 - \varepsilon \tan\beta_I)[dC_{TSi}/dx]dx \qquad [18]$$

Moment Due to Torque:

$$M_{Qb}(x_o) = [\rho \pi R^3 V^2/(2Z)] \int_{x_h}^{1} (x - x_o)(\tan\beta_I + \varepsilon)[dC_{TSi}/dx]dx \qquad [19]$$

Moments Parallel to Section Nose-Tail Line:

$$M_{xo}(x_o) = M_{Tb}\cos\phi + M_{Qb}\sin\phi \qquad [20]$$

Moment Perpendicular to Section Nose-Tail Line:

$$M_{yo}(x_o) = M_{Tb}\sin\phi - M_{Qb}\cos\phi \qquad [21]$$

Blade Loading Distribution:

$$LI(x) - (1/2)\rho c V_r^2 C_L \qquad [22]$$

where x, x_o = propeller nondimensional radial stations, r/R and r_o/R

ϕ = propeller pitch angle (input or β_I)

V_r = section inflow velocity, $V\sqrt{[(1-w_x)+U_A/2V]^2+[(x/\lambda_s)-U_T/2V]^2}$

Appendix A presents procedures for calculating propeller weight, center of gravity, mass polar moments of inertia and radius of gyration and Appendix B shows how the American Bureau of Shipping (ABS) coefficients and thickness requirements are calculated. Other

calculations made include stress calculations based on beam theory, parameters for making blade surface cavitation checks, chord lengths for making final pitch and camber calculations, and the prediction of spacing between blades and fillets at the propeller hub.

PROPELLER STRESS CALCULATIONS USING BEAM THEORY

A propeller blade must contain enough material to keep the stresses within a blade below a certain predetermined level. This level depends on the material properties with regard to both steady-state and fatigue strength and to both mean and unsteady blade loading. The material selection controls the allowable stress level and the blade chord, thickness, rake and skew are the main parameters which control the blade stress for a given blade loading. The principal stresses in the propeller blade are computed for each propeller. Both hydrodynamic and centrifugal loadings are considered. In this stress calculation procedure, the propeller blade is represented as a straight cantilever beam of variable cross-section without camber. Experimental results show that the neutral axis of an airfoil section lies approximately along the mean line so camber is not considered in the stress calculations presented. Only the maximum principal stresses calculated at the mid-chord of each section are printed as output in the computer program. Stresses

for the final design should be calculated by finite element techniques if rake and skew for the propeller differ from usual propeller shapes.

PARAMETERS FOR MAKING BLADE SURFACE CAVITATION CHECKS

Brockett's theoretically derived incipient cavitation charts of Reference 8 can be used to predict the blade surface cavitation characteristics of each propeller once the lifting line calculations have been completed. The two-dimensional camber to chord ratio (f_M/c), ideal angle of attack in degrees (α_i), section cavitation number (σ), nondimensionalized with the section inflow velocity (V_r), and the maximum and minimum fluctuating angle of attack (α_{max}, α_{min}) in degrees are parameters that must be determined before Brockett's incipient cavitation charts can be used. These parameters are calculated as follows:

Section Maximum Camber to Chord Ratio for NACA a=0.8 Meanline:

$$f_M/c=0.0679\ C_L \qquad [23]$$

Section Ideal Angle of Attack in Degrees for NACA a=0.8 Meanline:

$$\alpha_i=1.54\ C_L \qquad [24]$$

Section Cavitation Number:

$$\alpha=2g(H-xR)/V_r^2 \qquad [25]$$

where g = acceleration due to gravity

H = static head at shaft centerline (see section on Static Head).

The maximum and minimum fluctuating angles of attack

(α_{max},α_{min}) in degrees are calculated using the method derived by Lerbs and Rader in Reference 18. These calculations can be made using the following equations:

Maximum Fluctuating Angles of Attack:

$$\alpha_{max}=\alpha_i-(-\Delta\beta)F(x) \qquad [26]$$

Minimum Fluctuating Angles of Attack:

$$\alpha_{min}=\alpha_i-(+\Delta\beta)F(x) \qquad [27]$$

where $-\Delta\beta$ = Maximum effective angle of attack in degrees (from wake survey data), and

$+\Delta\beta$ = Minimum effective angle of attack in degrees (from wake survey data).

The parameter F(x) in Equations [26] and [27] is dependent on the hydrodynamic flow angle (β_I), the advance angle (β) and the lift coefficient (C_L), and is calculated on the computer using the following equation:

$$F(x)=1/[1+2\pi\tan(\beta_I-\beta)/C_L] \qquad [28]$$

The Burrill Cavitation Charts[7], can also be used to give an approximate check on the cavitation performance of propellers. Burrill's thrust loading coefficient (τ_C) and cavitation number ($\sigma_{0.7}$) at 0.7 radius defined as follows are parameters that must be known to use these cavitation charts.

18. Lerbs, H.W. and Rader, H.P., "Uber de Auftriebsgradienten von Profilen im Propeller Verband," Schiffstechnik, Vol. 9, No. 48, p 178-180, 1962

$$\tau_c = T/\{(\rho/2)A_p[\{V(1-w_{x=0.7})\}^2+\{0.7\pi nD\}^2]$$ [29]

Burrill Cavitation Number at 0.7 Radius:

$$\sigma_{0.7} = 2gH/[\{V(1-w_{x=0.7})\}^2+\{0.7\pi nD\}^2]$$ [30]

where A_E = propeller expanded area, $\int_{r_h}^{R} c\,dr$,

A_0 = propeller disc area, $\pi D^2/4$,

A_p = propeller projected area, $[1.067-0.229(P/D_i]A_E$, and

$(P/D)_i$ = propeller pitch ratio at 0.7 radius input or estimated as $0.7\pi\tan\beta_I$.

Keller's method[9] of predicting the minimum expanded area ratio of the propeller is also calculated on the computer. The minimum expanded area ratio, based on eliminating back bubble type cavitation, is computed as follows:

$$(A_E/A_0)_K = K_T(2.6+0.6Z)K_T/\{\sigma_{0.7}[J^2+(0.7\pi)^2\}$$ [31]

The constant K=0.15 was used in this program. Many possible alternate values of K may be desired, for example: K=0.2 is used for single screw ships with bronze propellers having rake of approximately 10 degrees, K=0.10 is used for twin screw ships with copper-aluminum propellers, K=0.15 is used for twin screw ships with bronze propellers and for single screw ships with copper-nickel-aluminum propellers, and K=0 to 0.05 is used for propellers for fast ships such as destroyers and frigates. If a different value of K is desired, the expanded area ratio calculated in equation [31] should be adjusted to account for changes in the value of K.

CHORD LENGTHS FOR PITCH AND CAMBER CALCULATIONS

The final pitch and camber for each propeller can be calculated using computer programs presented in References 3, 19, 20, 21, 22, and 23. The programs require as input the section chord length, $(c/R)_{LE}$ and $(c/R)_{TE}$ nondimensionalized on propeller radius, in terms of the skew angle (θ_S), hydrodynamic flow angle (β_I) and blade outline (c/D). The parameters $(c/R)_{LE}$ and $(c/R)_{TE}$ measured from the leading edge and trailing edge to its reference line, respectively, are calculated in the following manner on the computer:

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19. Kerwin, J.E., "The Solution of Propeller Lifting-Surface Problems by Vortex Lattice Methods," Department of the Naval Architecture and Marine Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1961
20. Kerwin, J.E., and Leopold, R., "Propeller Incidence Corection Due to Blade Thickness," Journal of Ship Research, Vol.7, No. 2, 1963
21. Cheng, H.M., "Hydordynamic Aspects of Propeller Design Based on Lifting-Surface Theory: Part I - Uniform Chordwise Load Distribution," David Taylor Model Basin Report 1802, 1964
22. Cheng, H.M., "Hydrodynamic Aspects of Propeller Design Based on Lifting Surface Theory: Part II - Arbitrary Chordwise Load Distribution, " David Taylor Model Basin Report 1803, 1965
23. Kerwin, J.E., "Computer Techniques for Propeller Blade Section Design," Transactions of the Second Lips Propeller Symposium, Drunen, Holland, p 1-31, May 1973

Chord Lengths Measured From Blade Leading Edge:

$$(c/R)_{LE}=x\theta_S/(57.296\ \cos\phi)-c/D \qquad [32]$$

Chord Lengths Measured From Blade Trailing Edge:

$$(c/R)_{TE}=x\theta_S/(57.296\ \cos\phi)+c/D \qquad [33]$$

($\phi=\beta_I$ is used when pitch is not input)

SPACING BETWEEN BLADES AND FILLETS

Propeller designs should have enough clearance between blades at the hub so fillets are properly applied. Hill, Reference 24, derived the following equation, which is used in the program to estimate spacing between blades at the hub without fillets:

$$G_Z = (2\pi r_h)/Z - (t_h/\sin\phi) \qquad [34]$$

where ϕ = input pitch or β_I

Based on a number of full-scale propellers built with standard fillets, Hill's blade clearance equation was modified in the following manner to estimate spacing between fillets at the hub during the preliminary stage of the design:

$$G_F = (2\pi r_h/Z) - (1.9t_h/\sin\phi) \qquad [35]$$

A layout of blade sections is recommended as a final fillet clearance check.

PROPELLER DESIGN THRUST AND POWER OPTIONS

The thrust option can be used to make lifting line calculations for propellers required to produce a given thrust at

24. Hill, J.G., "The Design of Propellers," Transactions of the Society of Naval Architects and Marine Engineers, Vol. 57, p 143-170, 1949.

specified values of speed and rpm (this is accomplished by adjusting the input tan β_I distribution), or the power option can be used if the propeller is required to absorb a specified power at a given rpm (in which case the speed is determined).

From each calculated power, a new value of speed (assumed to vary as the cube root of the ratio of the design and calculated power) is obtained and its corresponding effective power is obtained from the effective power input curve. Design calculations again produce a new calculated power, and the process continues until the closeness criteria of design calculated power is satisfied (two iterations are normally sufficient). Smaller increments of input speeds in general cause faster convergence.

Once the basic shape of the distribution is defined (see the Hydrodynamic Flow Angle Distribution section) the final $\tan\beta_I$ distribution $K_4 \tan\beta_I$ is determined using the thrust or power options, making lifting line calculations of three nondimensional thrust loading coefficients $(C_{Ts})_1$, $(C_{Ts})_2$, and $(C_{Ts})_3$ that correspond to three hydrodynamic pitch distributions, $K_1 \tan\beta_I$, $K_2 \tan\beta_I$, and $K_3 \tan\beta_I$ where $K_1 = 0.975$, $K_2 = 1.0$, and $K_3 = 1.025$. Once these calculations are obtained, the following system of equations are set up:

$$(C_{Ts})_1 = A+BK_1+CK_1^2$$
$$(C_{Ts})_2 = A+BK_2+CK_2^2$$
$$(C_{Ts})_3 = A+BK_3+CK_3^2$$

from which values of A, B, and C are obtained. Then, values of A, B, and C are substituted in the following equation to obtain the value of K_4.

$$C_{T_S} = A+BK_4+CK_4^2$$

where C_{T_S} = design thrust loading coefficient (Equation (7)).

COMPUTER PROGRAM AND SAMPLE DESIGN CALCULATIONS

Lifting line theory of References 1 and 2 has been used to derive a computer program for the preliminary design of propellers using high speed CDC computers at DTNSRDC. A core size of approximately 60,000 octal is required for the program. The average running time for a design based on thrust is 25 seconds and 100 seconds are required using the power option. As mentioned earlier, Appendix A presents procedures used to calculate propeller weight, center of gravity, mass polar moment of inertia, and radius of gyration. Appendix B shows how the American Bureau of Shipping (ABS) coefficients and thickness requirements are calculated. A detailed description of the input and output formulas for the computer program is present in Appendix C exercising most of the available options. Design calculations are presented in Appendix D for a sample design using the thrust option and results using the power option are shown in Appendix E. A Fortran listing of the computer program is presented in Appendix F.

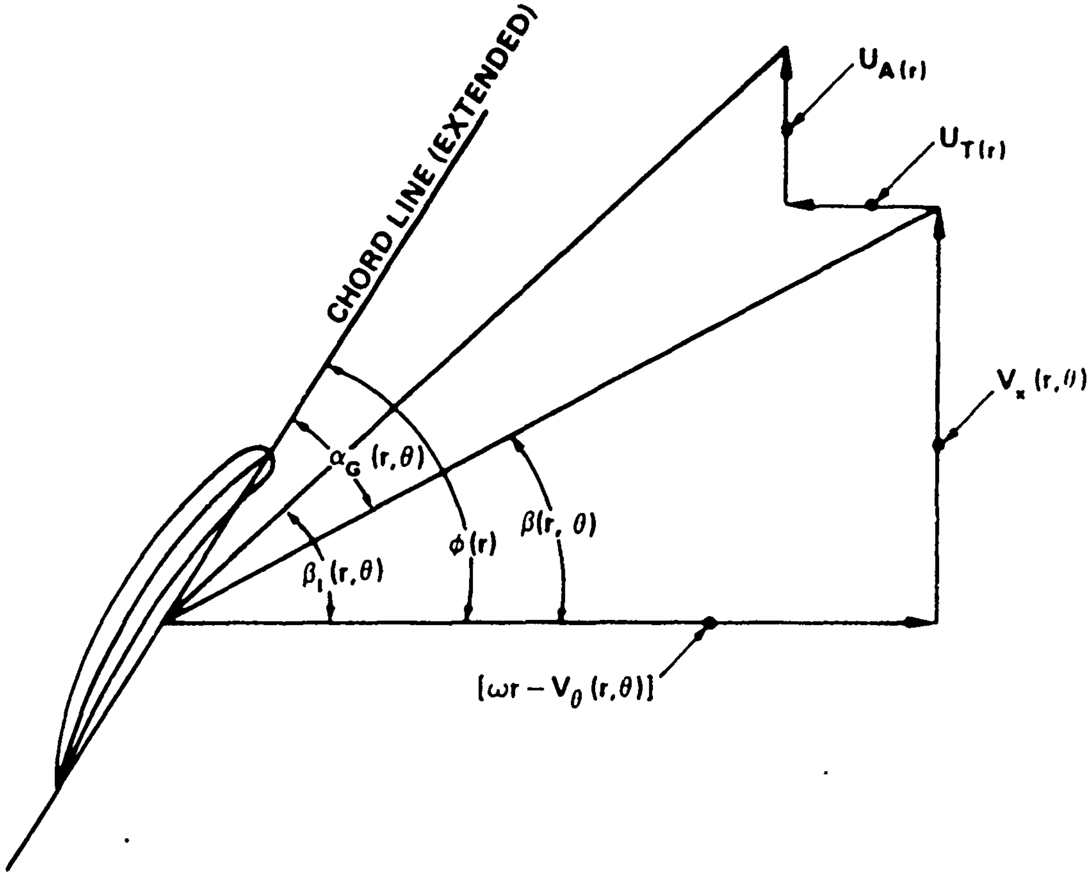


Figure 1 – Typical Velocity Diagram for a Propeller Blade Section at Radius r

(The diagram is drawn with all quantities positive and the velocity vectors represent the velocity of the propeller blade section relative to the fluid)

Figure 2 – Diagrams Showing Recommended Reference Lines and Terminology

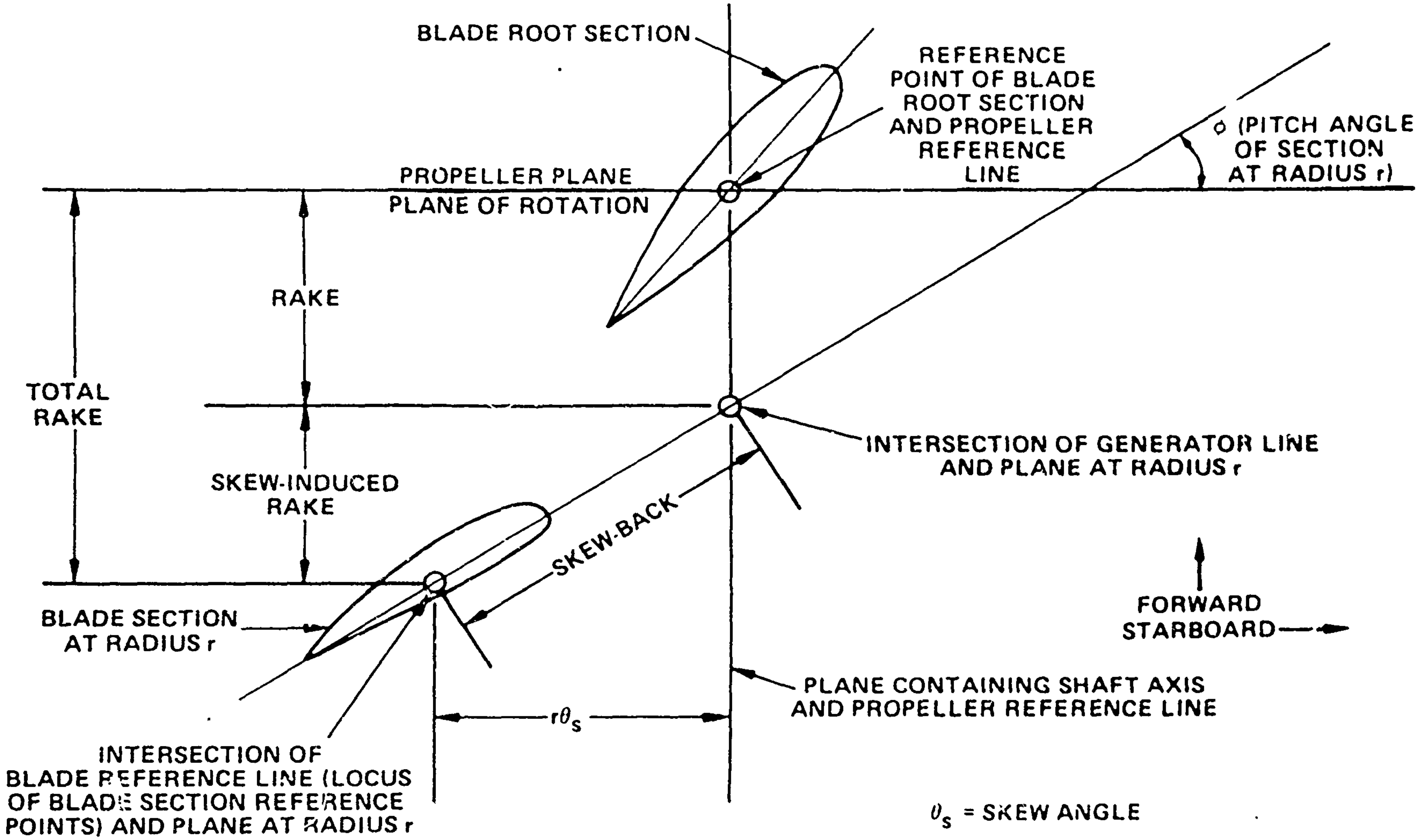


Figure 2a – View of Unrolled Cylindrical Sections at Blade Root and at Any Radius r of a Right-Handed Propeller (Looking Down) Showing Recommended Location of Propeller Plane

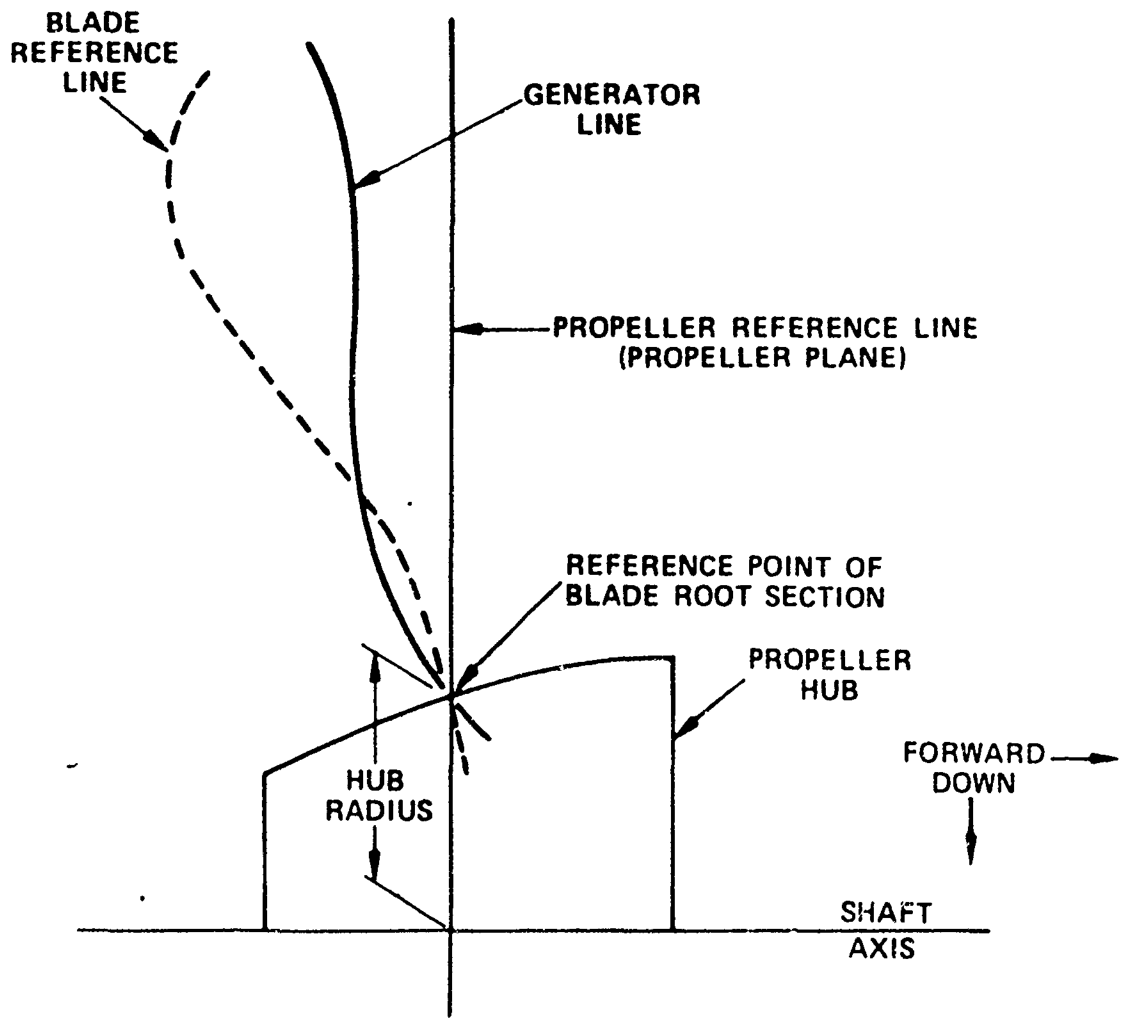
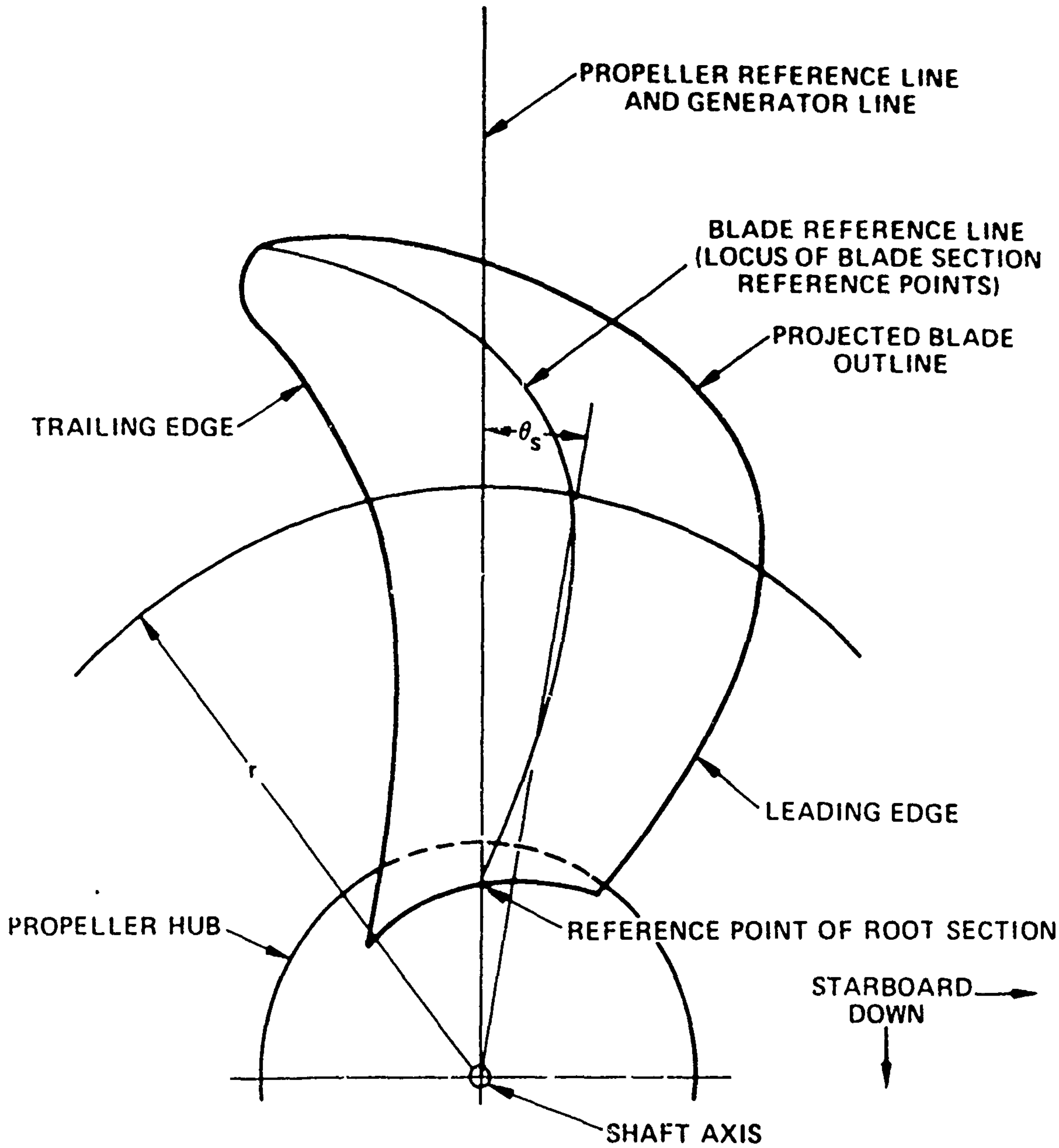


Figure 2b - Diagram Showing Recommended Reference Lines (Looking to Port)



NOTE: THE SKEW ANGLE, θ_S, SHOWN AT RADIUS r IS LESS THAN ZERO.

Figure 2c Diagram Showing Recommended Reference Lines (Looking Forward)

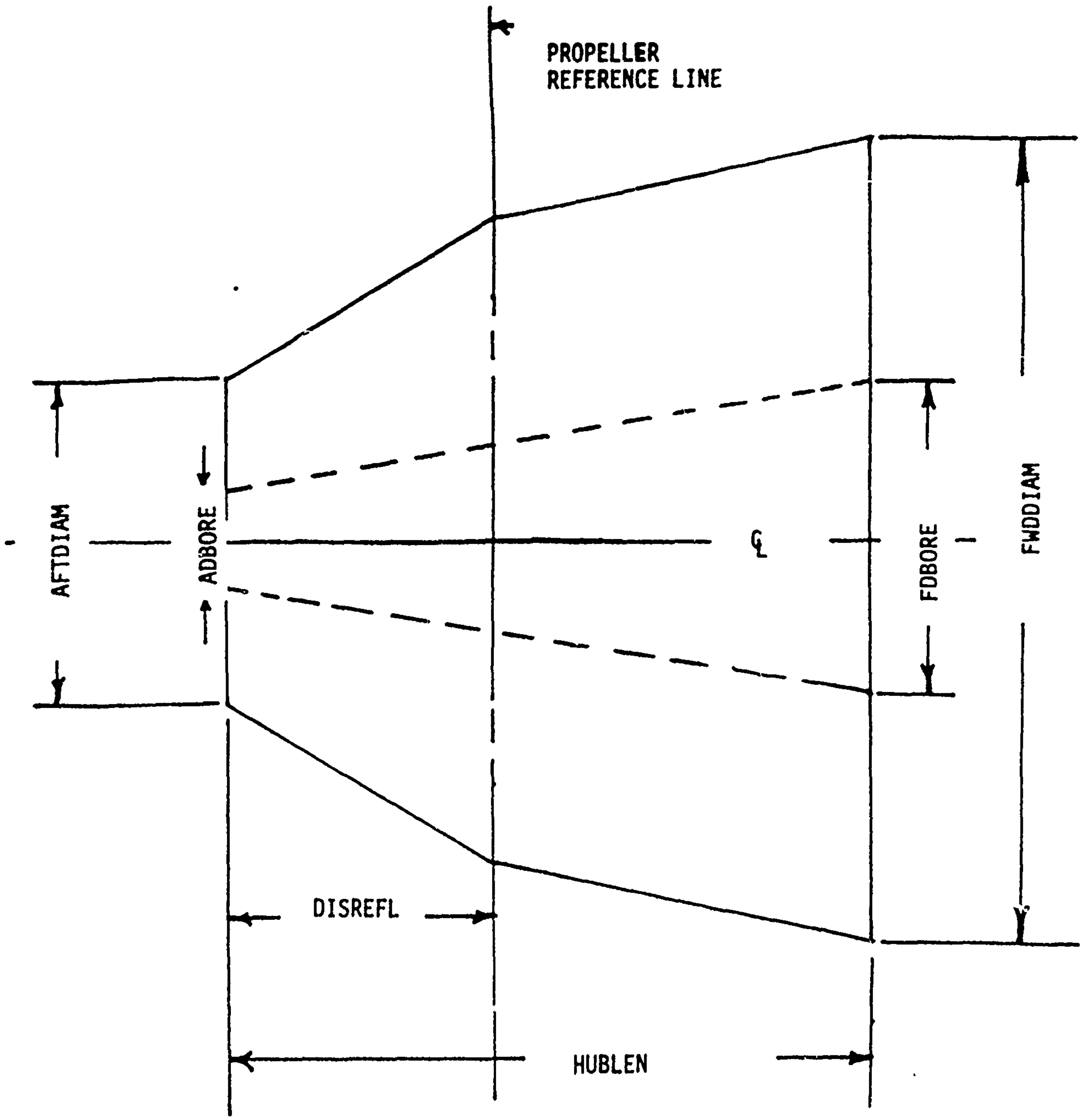


FIGURE 2d - INPUT FOR DETAILED HUB OPTION

TABLE 1

List of dimensioned input and output parameters used by computer program based on English and SI units

Parameter	English Units	SI Units	KSI[(1)]
Shaft power (P_S)	hp	KW	0.7457
Effective power (P_E)	hp	KW	0.7457
ρ_p	lbm/ft^3	kg/m^3	16.01846
V	knots[(2)]	m/s	0.514444
V	ft/sec	knots[(2)]	0.5924
D	ft	m	0.3048
H	ft	m	0.3048
ρ	$lbf\ sec^2/ft^4$	kg/m^3	515.3788
n	rev/min	rev/min[(3)]	1.0
T, weight	lbf	N	4.44822
V_r	ft/sec	m/s	0.3048
LI	lbf/ft	N/m	14.5939
M_{Tb}	in lbf	Nn	0.112985
M_{Qb}	in lbf	Nn	0.112985
M_{xo}	in lbf	Nn	0.112985
M_{yo}	in lbf	Nn	0.112985
Max Stress	lbf/in^2	Pa	6894.757
SKEW	deg	deg[(3)]	1.0
RAKE	deg	deg[(3)]	1.0
Mass polar moment of INERTIA	$lbm\ in^2$	kgm^2	0.00029264

(1) Multiply English Units by KSI to get SI Units.
(2) Computer program uses knots in both English Units option and SI Units option.
(3) These are not SI Units but are permitted to be used in the SI system according to International Standards Organization (150) Standard No. 1000.

APPENDIX A

PROPELLER WEIGHT, MASS POLAR MOMENTS OF INERTIA, AND CENTER OF GRAVITY

The approximate propeller weight (W_p) and location of center of gravity (CG) from the propeller center line is also calculated for each design. In order to make these calculations, the density of the material (ρ_p) must be specified as input.

Hub dimensions can be input, or a solid circular cylinder of equal length and diameter, with propeller center line at the mid length of the hub can be assumed. If the cylindrical hub is assumed:

$$W_p = W_B + W_H$$

where W_B = weight of blades, $\rho_p Z \int_{x_h}^{1} a(x)dx$

W_H = weight of hub, $(\pi \rho_p D_H^3/4)$,

D_H = hub diameter

$a(x)$ = area of section at radius x, $2c(x)t(x) \int_0^1 t(x,x_\ell)dx$,

$c(x)$ = chord length of section at radius x,

$t(x)$ = maximum thickness of section

$t(x,x_\ell)$ = Chordwise distribution of section thickness (NACA 66 modified thickness form is used in program)

x_ℓ = nondimensional coordinate along the section chord, (r_ℓ/c), and

ρ_p = density of material considered

if calculations are desired for a noncylindrical hub, the following dimensions are input:

D_{FH} = forward hub diameter,

D_A = aft hub diameter,

L_H = length of the hub,

D_{FB} = forward bore diameter,

L_{RL} = distance from aft end of hub to propeller reference line

The hub is then treated as consisting of two frustrums of cones, joined at the propeller reference line. Again

$W_p = W_B + W_H$,

but now

$W_H = W_{AF} + W_{FF} - W_b$

where W_{AF} = weight of solid aft frustum, $(\pi\rho_p/3)\ (D_{AH}D_H + D_H + D_H^2)/4$

W_{FF} = weight of solid forward frustum,

$(\pi\rho_p/3)\ (D_H^2 + D_H D_{FH} + D_{FH}^2)/4$

W_b = weight of bore, $(\pi\rho_p/3)\ (D_{AB}^2 + D_{AB}D_{FB} + D_{FB}^2)/4$

The propeller center of gravity (CG) with respect to the blade center line, where plus values represent the distance ahead of the center line and negative values aft of the center line, is calculated in the following manner (see Figures 2b and 2c):

Center of Gravity:

$CG = M_p/W_p$

where M_p = moment of the propeller, $\rho_p Z \int_{x_h}^{1} a(x)\ B(x)\ dx$

where M_p = moment of the propeller, $\rho_p Z \int_{x_h}^{1} a(x)\, B(x)\, dx$

$B(x)$ = distance of center of gravity from propeller reference line, $\bar{x} + \bar{y} + \bar{H}$

x = the distance of the center of gravity of the section along the chord line from the position of maximum thickness,

y = the distance between the center of gravity of the section and the chord line of the section, measured perpendicular to the chord line,

r_i = the radial distance from the shaft axis to the section,

θ_R = rake angle in radians of the section,

θ_S = skew angle in radians of the section, and

ϕ = pitch angle in radians of the section ($\phi = \beta_I$ is used when pitch is not input).

Then $\bar{x}$ = the component of the center of gravity adjusted for pitch, $x\sin\phi + y\cos\phi$;

$\bar{y}$ = the component of the center of gravity adjusted for skew $(= -\theta_S r_i \tan\phi)$ and rake $(= -\theta_R r_i/R)$; and

$\bar{H}$ = the component of the center of gravity along the shaft axis of the specified hub, aft of the propeller reference line taken as positive.

If the standard hub is selected,

H_{PM} = mass polar moment of hub = $W_H D_H^2/8$

otherwise,

$$H_{PM} = \pi \rho_p (A_{PM}+F_{PM}-B_{PM})/10$$

where A_{PM} = aft mass polar moment =

$$L_{RL}\ (D_H^4+D_H^3 D_{AH}+D_H^2 D_{AH}^2+D_H D_{AH}^3+D_{AH}^4)/16$$

F_{PM} = forward mass polar moment =

$$(H_L-L_{RL})(D_H^4+D_H^3 D_{FH}+D_H^2 D_{FH}^2+D_H D_{FH}^3+D_{FH}^4)/16$$

B_{PM} = mass polar moment of bore =

$$H_L (D_{AB}^4+D_{AB}^3 D_{FB}+D_{AB}^2 D_{FB}^2+D_{AB} D_{FB}^3+D_{FB}^4)/16$$

Z_{PM} = mass polar moment of blades =

$$Z \rho_p R^3 \int_{x_h}^{1} X^2 \epsilon_r(x)\, dx$$

Then P_{PM} = propeller mass polar moment=

$$Z_{PM}+H_{PM}$$

and K_Z = radius of gyration of blades =

$$\sqrt{Z_{PM}/W_B}$$

K_H = Radius of gyration of hub =

$$\sqrt{H_{PM}/W_H}$$

K_P = radius of gyration of propeller =

$$\sqrt{P_{PM}/W_P}$$

APPENDIX B

AMERICAN BUREAU OF SHIPPING (ABS) COEFFICIENT AND THICKNESS REQUIREMENTS

The minimum blade thickness at the one-quarter radius is defined in Reference 25 by:

$$t_1 = K_1\sqrt{AP_S/(C_N CZn)} + C_S BZ_R/(4C_N C)$$

and

$$T_2 = K_1\sqrt{AP_S/(C_N CZn)} + C_S BZ_T/(4C_N C)$$

where P_S = shaft power at the maximum continuous rating,

n = propeller revolutions per minute rpm at the maximum continuous rating,

Z = number of blades,

Z_R = rake, positive aft, at the blade tip.

Z_R, Z_T = rake and rake plus skew induced rake, at the blade tip, positive aft taken as positive,

and

$C_S = a_s/(W_s t_{0.25})$ = section area coefficient at the one-quarter radius

$C_N = I_o/(U_f W_S t^2_{0.25})$ = section modulus coefficient at the one-quarter radius

$A = 1+(K_2/\tan\phi_{0.7})+K_3\tan\phi_{0.25}$

$B = (K_4(A_E/A_0)/(Z) \quad (n/100)^2 \; (D/20)^3$

$C = (1+K_5 \tan\phi_{0.25})W_S f-B)$

where K_1 through K_5 are constants which depend on the system of units employed

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25. American Bureau of Shipping, "Rules for Building and Classing Steel Vessels," p 621, 1972.

a_S = area of expanded cylindrical section at 0.25R =

$2c_{0.25}t_{0.25} \int_0^1 t(0.25,x)\,dx$,

W_S = expanded width of cylindrical section at the one-quarter radius,

$t_{0.25}$ = maximum thickness at the one-quarter radius,

I_0 = moment of inertia of the expanded cylindrical section at one-quarter radius about a straight line through the center of gravity parallel to the chord line,

U_F = maximum normal distance from the moment of inertia axis to points on the face of the section,

$c_{0.25}$ = section chord length at 0.25R,

$\phi_{0.25}$, $\phi_{0.7}$ = the pitch angles at the one-quarter and seven-tenths radius (or β_I if ϕ not input),

t(0.25,x) = chordwise distribution of section thicknesses at the 0.25 radius

A_E/A_0 = expanded blade area divided by the disc area,

D = propeller diameter,

f = material constants in length/weight as a function of w

w = a nondimensional parameter associated with the material type as illustrated in the table below.

Type	Materials	Units w
2	Manganese bronze	0.30
3	Nickel-manganese bronze	0.29
4	Nickel-aluminum bronze	0.27
5	Mn-Ni-Al bronze	0.27
6	Cast iron	0.26

If $C_N \neq 0.1$, the thicknesses t_1 and t_2 are recomputed with C_N=0.1.

APPENDIX C

DESCRIPTION OF INPUT AND OUTPUT

Data are input to the program in unformatted groups. Within each group the data must be in the order specified, and each value must be separated from all others by a blank or comma. Variable names beginning with I,J,K,L,M, or N require an integer input, but other variables which happen to have integer values do not require a decimal point. Zeroes must actually be keypunched. Beyond this there are no restrictions on how many or few data cards are needed for a group, except that each group must start with a new card. The input required is as follows:

Group	Parameters	Description of Input
1	IDD	Number of data sets(each of the groups 2 through end form a data set)
2	UI,UO,Title	Use SI in columns 2,3 to pecify input in SI units. Use SI in columns 4, 5 for output in SI units. The remaining 66 columns are available for identification of input data.
3	SHP[FL/T]	Design shaft power or 0 if the thrust option is desired *
	TANBI	Use 1 unless use of an exact (not adjusted by program) $\tan\beta_I$ distribution is required, then use 0 (see hydrodynamic flow angle distribution
	TANB	Use 1 to input $\tan\beta$ distribution, or 0 for machine calculations according to (2)
	XPS	Use -1 to input a skew distribution, or input the skew at the tip for a linear skew distribution (both in degrees)
	RAKE	Use <RAKE$\leq$ 0.01 to input a rake/D distribution or input the rake/D at the tip for a linear distribution *
	PDO	Use PDO 0 to input a P/D distribution, otherwise π $x\tan\beta_I$ is used as an approximation

* As used within the Fortran Program

Group	Parameter	Description of Input
	CD	Use CD$\geq$10 to input the radial distribution of drag coefficients (CD); 0<CD<10 to input a constant drag C_D=CD at all radial stations; CD=0 causes the computer program to calculate the radial distribution of drag coefficients using the equation $C_D=0.008[1+1.25(t/c)+125(t/c)^4]$; -10<CD<0 causes the computer program to use a constant frictional resistance C_{FO}=ABS(C_{FO}) in Equation 6 $C_D=C_{FO}[1+1.25(t/c)+125(t/c)^4]$; CD$\leq$-10 to input the radial distribution of frictional resistance (CFO) values to be used in Equation 6.
3	TYPE	For ABS minimum blade thickness calculations coefficients use the number corresponding to the material type in the blade thickness section. Use TYPE=0 to suppress these calculations
	HUB	Use HUB$\neq$0 to input actual dimensions of HUB, or HUB=0 to use solid cylindrical hub in relevant calculations
4	DIAM[L]	Propeller diameter
	EWAKE	Effective wake ($1-w_T$)
	ETHRUS	Thrust deduction (1-t)

Group	Parameters	Description of Input
	HEAD[L]	See section on Static Head, at the shaft centerline
	DEN[M/L3]	Density of propeller materials
	RHO[M/L3]	Density to be used for water
5	IVV	Number of velocities input
	VE1[L/T]	IVV velocities
	EHP[FL/T]	IVV design effective power values, corresponding to the input velocities
5	IZZ	Number of different blade numbers input
	JBL	IZZ values of blade numbers
	IEA	Number of expanded area ratios input
	EXX	IEA values of A_E/A_O. A value of 0 input as the first A_E/A_O will result in calculations being done exactly at the design A_E/A_O. If this default is used, calculations will not be done at other values of A_E/A_O in the list that happen to be within 0.005 of the design A_E/A_O.
	IRPM	Number of different rpms input
	XMM	IRPM values of revolutions per minute

Group	Parameters	Description of Input
(The remaining five radial distributions have eleven values each)		
	X3	Values of r/R at which other radial distributions are defined
	X4	Propeller wake $(1-w_x)$
	X5	Hydrodynamic flow angles $(\tan\beta_I)$. If zeroes are input, Lerbs optimum is calculated as a default distribution
	X6	Section chord lengths (c/D)
	AZZ(25)	Thickness to chord ratios
(Groups six through ten which are specified in group three are defined at the eleven radial stations)		
6	AZZ(24)	Blade skew angles, degrees (if XPS<0)
7	B(7)	Section drag coefficients (if CF>10) or frictional resistance of section C_{FO} (if CD$\leq$-10
8	B(8)	Tangents of advance angles (if TANB>0)
9	RAK	Rake/D, aft positive (if 0<RAKE$\leq$0.01)
10	P	Pitch, P/D (if PD>0)
11	FWDDIAM[L]	Dimensions, as indicated in Figure 2d (if HUB≠0)
	AFTDIAM[L]	
	HUBLEN[L]	
	FDBORE[L]	
	ADBORE[L]	
	DISREFL[L]	

A Description of the Output Generated by the Program Follows:

Program Output	Description
G	Nondimensional circulation
UT/2V	Tangential velocity induced at lifting line
UA/2V	Axial velocity induced at lifting line
DCTSI	Local nonviscous thrust coefficient (Defined in Equation (9))
DCPSI	Local nonviscous power coefficient (Defined in Equation (11))
VR [L/T]	Section inflow velocity, equation (22)
CAVV	Section cavitation number, Equation (25)
CPTI	Nonviscous thrust power coefficient (Equation (10) when $\varepsilon=0$).
CPSI	Nonviscous power coefficient (Equation (11) when $\varepsilon=0$)
ETAI	Estimated nonviscous propeller efficiency (Equation (12) when $\varepsilon=0$)
CTSI	Nonviscous thrust coefficient (Equation (9) when $\varepsilon=0$)
CPT	Thrust power loading coefficient (Equation (10))
CPS	Power loading coefficient (Equation (11)).
TETS	Projected skew angle in degrees
RAKG	Rake/Diameter
PE	Effective power

Program Output	Description
PS	Shaft power
ETA	Estimated propeller efficiency (Equation (12)
CTS	Thrust loading coefficient (Equation (9))
CL	Section lift coefficient
ALI	Section two-dimensional ideal angle of attack in degrees for NACA a=0.8 meanline, Equation (24)
FM/C	Section two-dimensional maximum camber ratio for NACA a=0.8 meanline, Equation (23)
CD/CL	Section drag-lift ratio ($\epsilon=C_D/C_L$)
F(X)	Parameter for calculations section fluctuating angles of attack, Equation (28)
LI[F/L]	Propeller blade loading distribution Equation (22)
(C/R)DLE	Chord lengths for lifting surface pitch and camber calculations, Equation (32)
(C/R)DTE	Chord lengths for lifting surface pitch and camber calculations, Equation (33)
T/RD	Ratio of section thickness to radius
PC	Estimated propulsive efficiency, Equation (13)
PS[FL/T]	Calculated shaft power delivered at the propeller, Equation (13)
DESIGN [F]	Design thrust
CALCULATED [F]	Calculated thrust, Equation (7) and (9)

Program Output	Description
AEPA [L^2]	Area of section
XBAR [L]	Longitudinal position about x axis parallel to nose-tail line from centroid
YBAR [L]	Vertical distance about y axis perpendicular to nose-tail line from centroid
IXO [L^4]	Moment of inertia about y axis perpendicular to nose-tail line
MXO [FL]	Bending moment about the x axis, Equation [20]
MYO [FL]	Bending moment about the y axis, Equation [21]
MTB [FL]	Bending moment due to thrust, Equation [18]
MQB [FL]	Bending moment due to torque, Equation [19]
MAX STRESS (F/L^2]	Maximum stress
WEIGHT OF BLADES [F]	Equation [32], W_H=0
WEIGHT OF PROP (BLADES +DESIGNATED HUB) [F]	
(CENTER OF GRAVITY OF PROP/D)	Appendix A
(CENTER OF GRAVITY OF BLADES/D)	Appendix A
KELLERS MINIMUM EAR	Equation [31]
SPEED COEFF(JS)	Equation [15]

Program Output	Description
Advance Coeff (JA)	Equation [14]
THRUST COEFF (KT)	Equation [16]
TORQUE COEFF (KQ)	Equation [17]
PROPULSIVE EFFICIENCY (PC)	Equation [13]
BURRILL THRUST COEFF (TC)	Equation [29]
BURRILL CAVITATION COEFF	Equation [30]
CLEARANCE AT HUB BETWEEN BLADES/D	Equation [34]
CLEARANCE AT HUB BETWEEN FILLETS/D	Equation [35]
MASS POLAR MOMENT OF INERTIA OF BLADES [FL^2]	Appendix A
TOTAL MASS POLAR MOMENT OF INERTIA [FL^2]	"
RADIUS OF GYRATION OF BLADES/D	"
RADIUS OF GYRATION OF HUB/D	"
TOTAL RADIUS OF GYRATION/D	"
ABS MINIMUM THICKNESS CONVENTIONAL RAKE	Appendix B
CONVENTIONAL + SKEW INDUCED RAKE/D	"
VALUES USED IN DETERMINING THICKNESS	"

Program Output	Description
SECTION AREA COEFFICIENT	Appendix B
SECTION MODULUS COEFFICIENT	"
AREA OF EXPANDED CYLINDRICAL SECTION [L^2]	"

APPENDIX D

SAMPLE DESIGN USING THE THRUST OPTION

OPTIONS EXERCISED IN APPENDIX D

Power or thrust	T
Calculations with input $\tan\beta_I$	N/A
$\tan\beta_I$ (Lerbs or input)	Input
$\tan\beta$ (Calculated from $(1-w_x)$ or input)	Input
C_D (constant, variable, or calculated)	Const
Multiple RPM	No
Multiple Z	No
Multiple AE/AO	No
Check AE/AO of input C/D and modify	No
Skew (Linear/Nonlinear)	L
Rake (Linear/Nonlinear)	L
P/D (input or approximated by $\pi x \tan\beta_I$)	Input
ABS coefficients	No
Hub geometry	Input
Input Units	SI
Output Units	SI

AML GENERAL PURPOSE 80 COLUMN SHEET

NDW-NSRDC-5223/7 (979)

```
SICT  CASE 3
0 1 1 60 -.02348 1 .0025 4 1
7.0104 .785 .837 15.8496 7750.3717 1025.8615
5 12.689 12.347 12.604 12.707 12.861 15414 15478 16589 17190 18103
1 6 2 0 .758 1 1.26
.176 .25 .3 .4 .5 .6 .7 .8 .9 .95 1.
.4358 .4741 .5525 .6642 .7508 .79 .8142 .8393 .8625 .8705 .8776
1.3722 1.0286 .90637 .74535 .63396 .54192 .47156 .41868 .37742 .35929 .3427
.191 .2196 .2377 .2648 .2816 .2876 .2807 .2564 .2029 .1523 0
.216 .1785 .1539 .125 .1017 .0796 .0609 .0468 .0394 .0432 0
.80222 .64031 .59666 .53797 .48649 .42657 .37683 .33949 .31048 .29687 .28432
1.34 1.325 1.274 1.257 1.248 1.176 1.07 .968 .925 .91 .901
1.27 1.143 1.3716 .7059 .5916 .6858
```

REMARKS

SISI CASE B

THRUST OPTION, DENSITY OF PROP(KG/M3)= 7750.3717

V(M/SEC)	1.2085E+01	1.2347E+01	1.2604E+01	1.2707E+01	1.2961E+01
PE(KW)	1.4414E+04	1.5478E+04	1.6589E+04	1.7190E+04	1.8103E+04

D(M) = 7.0104 ,1-WTT=.7850 ,1-THD=.8370 ,H(M) = 15.8496 ,RHO(KG/M3) = 1025.8615

Z	6	
AE/AO	7.6483E-01	7.6800E-01
N(REV/MIN)	1.0600E+02	

X INPUT	1-WX INPUT	C/D INPUT	T/C INPUT	TANBI INPUT	TANB INPUT	TETS(DEG) LINEAR	RAKG/D LINEAR	P/D INPUT	CD INPUT
1.7600E-01	4.3590E-01	1.9100E-01	2.1600E-01	1.3722E+00	8.0222E-01	0.	0.	1.3400E+00	8.5000E-03
2.5000E-01	4.9410E-01	2.1960E-01	1.7880E-01	1.0286E+00	6.4031E-01	5.3889E+00	-5.39[illegible]E-03	1.3250E+00	8.5000E-03
3.0000E-01	5.5250E-01	2.3790E-01	1.5890E-01	9.0639E-01	5.9666E-01	9.0291E+00	-1.4057E-02	1.2740E+00	8.5000E-03
4.0000E-01	6.6420E-01	2.6480E-01	1.2800E-01	7.4535E-01	5.3797E-01	1.6311E+01	-2.5412E-02	1.2[illegible]70E+00	8.5000E-03
5.0000E-01	7.5090E-01	2.9160E-01	1.0190E-01	6.3396E-01	4.8649E-01	2.3592E+01	-3.6757E-02	1.2480E+00	8.5000E-03
6.0000E-01	7.9010E-01	2.8760E-01	7.9600E-02	5.4192E-01	4.2657E-01	3.0874E+01	-4.8101E-02	1.1750E+00	8.5000E-03
7.0000E-01	8.1420E-01	2.8070E-01	6.0930E-02	4.7156E-01	3.7653E-01	3.9155E+01	-5.9446E-02	1.0700E+00	8.5000E-03
8.0000E-01	8.3930E-01	2.5540E-01	4.6800E-02	4.1868E-01	3.3949E-01	4.5437E+01	-7.0791E-02	9.6800E-01	8.5000E-03
9.0000E-01	8.6250E-01	2.0290E-01	3.9430E-02	3.7749E-01	3.1045E-01	5.2718E+01	-8.2135E-02	9.2500E-01	8.5000E-03
9.5000E-01	8.7650E-01	1.5280E-01	4.3230E-02	3.5929E-01	2.9687E-01	5.6359E+01	-8.7808E-02	9.1000E-01	8.5000E-03
1.0000E+00	5.7760E-01	0.	0.	3.4270E-01	2.8432E-01	6.0000E+01	-9.3480E-02	9.0100E-01	8.5000E-03

X	TANBI	TAN B	G	UT/2V	UA/2V	OCYSI	OCPSI	VR(M/SEC)	CAVV
1.7600E-01	1.3679E+00	8.0222E-01	0.	1.7216E-01	7.1790E-02	0.	0.	7.6011E+00	4.5187E+00
2.5000E-01	1.0253E+00	6.4031E-01	1.2482E-02	1.7303E-01	1.2278E-01	1.8023E-01	1.4260E-01	1.0417E+01	2.5213E+00
3.0000E-01	9.0352E-01	5.9666E-01	1.4922E-02	1.5913E-01	1.4037E-01	2.7463E-01	2.2977E-01	1.2494E+01	1.7749E+00
4.0000E-01	7.4299E-01	5.3797E-01	1.6993E-02	1.3142E-01	1.5549E-01	4.4993E-01	4.1273E-01	1.6615E+01	1.0071E+00
5.0000E-01	6.3195E-01	4.8649E-01	1.7594E-02	1.[illegible]E-01	1.5714E-01	6.0666E-01	5.9167E-01	2.0546E+01	6.4988E-01
6.0000E-01	5.4020E-01	4.2657E-01	1.7838E-02	9.1115E-02	1.6123E-01	7.5383E-01	7.5417E-01	2.4195E+01	4.5869E-01
7.0000E-01	4.7007E-01	3.7653E-01	1.7622E-02	7.9539E-02	1.6409E-01	8.8[illegible]19E-01	8.9397E-01	2.7800E+01	3.3913E-01
8.0000E-01	4.1735E-01	3.3949E-01	1.6462E-02	6.9409E-02	1.6330E-01	9.4915E-01	9.7714E-01	3.1437E+01	2.5851E-01
9.0000E-01	3.7629E-01	3.1045E-01	1.3350E-02	6.3653E-02	1.6901E-01	8.7061E-01	9.1097E-01	3.5098E+01	2.0195E-01
9.5000E-01	3.5814E-01	2.9687E-01	1.0133E-02	5.7259E-02	1.5916E-01	6.9917E-01	7.3424E-01	3.6917E+01	1.8003E-01
1.0000E+00	3.4161E-01	2.8432E-01	0.	5.4223E-02	1.5933E-01	0.	0.	3.8739E+01	1.6122E-01

CPTI=3.9583E-01	CPSI=5.0174E-01	ETAI=7.8890E-01	CTSI=5.0377E-01	CTSI/CPSI=1.0040E+00
CPT=3.8681E-01	CPS=5.5393E-01	ETA=6.9830E-01	CTS=4.9232E-01	CTS/CPS=9.8879E-01

X	CL	ALI(DEG)	FM/C	CD/CL	F(X)	LI(N/M)	TETS(DEG)	(C/RO)LE	(C/RO)TE	T/RO
1.760E-01	0.	0.	0.	0.	0.	0.	0.	-1.910E-01	1.913E-01	8.251E-02
2.500E-01	4.145E-01	6.383E-01	2.814E-02	2.051E-02	2.211E-01	3.551E+04	5.388E+00	-1.735E-01	2.657E-01	7.853E-02
3.000E-01	3.813E-01	5.872E-01	2.583E-02	2.229E-02	2.334E-01	5.092E+04	9.029E+00	-1.584E-01	3.174E-01	7.560E-02
4.000E-01	2.934E-01	4.518E-01	1.992E-02	2.897E-02	2.417E-01	7.711E+04	1.631E+01	-1.037E-01	4.259E-01	6.779E-02
5.000E-01	2.310E-01	3.557E-01	1.564E-02	3.680E-02	2.494E-01	9.973E+04	2.359E+01	-1.865E-02	5.444E-01	5.739E-02
6.000E-01	1.947E-01	2.999E-01	1.327E-02	4.365E-02	2.512E-01	1.179E+05	3.087E+01	9.347E-02	6.687E-01	4.579E-02
7.000E-01	1.715E-01	2.642E-01	1.165E-02	4.955E-02	2.563E-01	1.318E+05	3.816E+01	2.377E-01	7.991E-01	3.419E-02
8.000E-01	1.551E-01	2.389E-01	1.053E-02	5.479E-02	2.658E-01	1.413E+05	4.544E+01	4.234E-01	9.362E-01	2.400E-02
9.000E-01	1.424E-01	2.193E-01	9.663E-03	5.970E-02	2.777E-01	1.290E+05	5.272E+01	6.684E-01	1.074E+00	1.599E-02
9.500E-01	1.364E-01	2.101E-01	9.264E-03	6.230E-02	2.817E-01	1.022E+05	5.636E+01	8.241E-01	1.130E+00	1.320E-02
1.000E+00	0.	0.	0.	0.	0.	0.	6.000E+01	1.089E+00	1.083E+00	0.

ETAD=7.4391E-01   PS(KW) =1.9376E+04   1-THD=8.3700E-01   1-WTT=7.8510E-01   V(KNOTS) =2.3499E+01   DESIGN TH(N) =1.4245E+06
Z= 6   N(REV/MIN)=1.0600E+02   AE/AO=7.6483E-01   V(M/SEC) =1.2089E+01   CALCULATED TH(N) =1.4245E+06

X	AREA(M2)	XBAR(M)	YBAR(M)	IXO(M4)	IYO(M4)	MXO(N-M)	MYO(N-M)	MTB(N-M)	MOB(N-M)	MAXSTRESS(PA)
1.760E-01	2.792E-01	6.333E-01	0.	1.373E-03	2.833E-02	2.941E+05	1.928E+06	4.114E+05	2.179E+05	4.490E+07
3.000E-01	3.187E-01	7.886E-01	3.082E-03	1.315E-03	5.016E-02	2.170E+05	1.327E+06	3.194E+05	1.586E+05	3.304E+07
4.000E-01	3.130E-01	8.780E-01	2.221E-03	1.055E-03	6.202E-02	1.792E+05	1.079E+06	2.320E+05	1.155E+05	2.763E+07
5.000E-01	2.863E-01	9.337E-01	1.578E-03	6.811E-04	6.315E-02	1.113E+05	5.892E+05	1.620E+05	7.823E+04	2.400E+07
6.000E-01	2.333E-01	9.536E-01	8.273E-04	3.532E-04	5.357E-02	6.676E+04	4.167E+05	1.022E+05	4.787E+04	2.405E+07
7.000E-01	1.700E-01	9.327E-01	0.	1.435E-04	3.726E-02	3.337E+04	2.499E+05	5.452E+04	2.479E+04	2.469E+07
8.000E-01	1.090E-01	8.521E-01	0.	4.535E-05	1.993E-02	1.724E+04	8.439E+04	2.709E+04	3.729E+03	2.348E+07

X	RAKG/D	PI XTANPI	PI XTANB
1.760E-01	0.	7.543E-01	4.436E-01
2.500E-01	-8.395E-03	8.053E-01	5.029E-01
3.000E-01	-1.437E-02	8.515E-01	5.623E-01
4.000E-01	-2.541E-02	9.337E-01	6.760E-01
5.000E-01	-3.676E-02	9.927E-01	7.642E-01
6.000E-01	-4.810E-02	1.018E+00	8.041E-01
7.000E-01	-5.945E-02	1.034E+00	8.287E-01
8.000E-01	-7.079E-02	1.049E+00	8.537E-01
9.000E-01	-8.214E-02	1.064E+00	8.779E-01
9.500E-01	-8.781E-02	1.069E+00	8.863E-01
1.000E+00	-9.348E-02	1.073E+00	8.922E-01

WEIGHT OF BLADES(N) = 273758.4944

WEIGHT OF PROP (BLADES + DESIGNATED HUB)(N) = 361222.8754

CENTER OF GRAVITY OF PROP REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= .021136

CENTER OF GRAVITY OF BLADES REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= .023669

HUB DIMENSIONS/D
LENGTH= .1957
FWD DIAM= .1912
AFT DIAM= .1630
MIDCHORD OF ROOT SECTION TO AFT END OF HUB= .0978
HUB DIAM AT MIDCHORD OF ROOT SECTION= .1760
FWD DIAM OF BORE= .1307
AFT DIAM OF BORE= .0844

KELLERS MINIMUM EAR= .7177E+00

SPEED COEFF V/(ND) JS= .9761E+00

ADVANCE COEFF V(1-WTT)/(ND) JA= .7662E+00

DESIGN THRUST COEFF KT= .1842E+00

TORQUE COEFF KQ= .3220E-01

PROPULSIVE EFFICIENCY ETAD= .7439E+00

BURRILL THRUST COEFF TC= .1351E+00

BURRILL CAVITATION COEFF SIGMA(0.7)= .3710E+00

CLEARANCE AT HUB BETWEEN BLADES/D= 4.7523E-02

CLEARANCE AT HUB BETWEEN FILLETS/D= 7.3561E-03

```
MASS POLAR MOMENT OF INERTIA OF BLADES (KG-M2)=   .771877E+05

TOTAL MASS POLAR MOMENT OF INERTIA (KG-M2)=   .793262E+05

RADIUS OF GYRATION OF BLADE/D=   .2372

RADIUS OF GYRATION OF HUB/D=   .0693

TOTAL RADIUS OF GYRATION/D=   .2093


        ABS COEFFICIENTS (CALCULATED AT THE .25 RADIUS)

ABS MINIMUM THICKNESS IN INCHES (USING P/D INPUT)-
                    USING ABS RAKE = CONVENTIONAL RAKE,  T/D=  .2656E-01
                    USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D=  .3183E-01

VALUES USED IN DETERMINING THICKNESS-      A=  .123053E+02
                                           B=  .252302E+03
                                           C=  .146355E+05

SECTION AREA COEFFICIENT      CS=  .6942E+00

SECTION MODULUS COEFFICIENT      CN=  .8558E-01

AREA OF EXPANDED CYLINDRICAL SECTION IN SQ.METERS      AS= .2942E+00



FOR CN=.1
ABS MINIMUM THICKNESS IN INCHES (USING P/D INPUT)-
                    USING ABS RAKE = CONVENTIONAL RAKE,  T/D=  .2490E-01
                    USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D=  .2931E-01
```

RADIAL PROPELLER DATA FOR INPUT INTO DESIGN PROGRAMS(8 RADIAL STRIPS ASSUMED)

XR	TAN BETA I	G	XSL(METERS)	XST(METERS)	1-WX	UA/2VS	THICKNESS(METERS)
.22750	1.10757	.1023E-01	-.62651	.85114	.47103	.1111E+00	.27947
.27930	.94930	.1420E-01	-.58011	1.03598	.52733	.1342E+00	.26952
.39200	.76557	.1679E-01	-.40629	1.47172	.64531	.1542E+00	.24327
.49500	.64701	.1754E-01	-.11619	1.84495	.74091	.1569E+00	.20701
.59800	.55006	.1783E-01	.27502	2.29050	.78556	.1607E+00	.16546
.69100	.47559	.1767E-01	.78244	2.75878	.81214	.1640E+00	.12339
.79400	.42013	.1657E-01	1.44332	3.25187	.83678	.1635E+00	.08609
.89700	.37743	.1345E-01	2.31576	3.74934	.86194	.1601E+00	.05632
.94850	.35867	.1030E-01	2.86859	3.95737	.87029	.1592E+00	.04688
1.00000			3.81961	3.81961			

SISI CASE B

THRUST OPTION, DENSITY OF PROP(KG/M3)= 7750.3717

V(M/SEC) 1.2089E+01 1.2347E+01 1.2604E+01 1.2707E+01 1.2861E+01
PE(KW) 1.4414E+04 1.5475E+04 1.6589E+04 1.7190E+04 1.8103E+04

D(M) = 7.0104 ,1-WTT=.7850 ,1-THO=.8370 ,H(M) = 15.5496 ,RHO(KG/M3) = 1025.8615

Z 6
AE/A0 7.6483E-01 7.6800E-01
N(REV/MIN) 1.0600E+02

X INPUT	1 WX INPUT	C/D INPUT	T/C INPUT	TANBI INPUT	TANB INPUT	TETS(DEG) LINEAR	RAKG/D LINEAR	P/D INPUT	CD INPUT
1.7600E-01	4.3580E-01	1.9100E-01	2.1600E-01	1.3679E+00	8.0222E-01	0.	0.	1.3400E+00	8.5000E-03
2.5000E-01	4.9410E-01	2.1950E-01	1.7380E-01	1.0253E+00	6.4031E-01	5.3853E+00	-8.3950E-03	1.3250E+00	8.5000E-03
3.0000E-01	5.5250E-01	2.3790E-01	1.5890E-01	9.0352E-01	5.9566E-01	9.0291E+00	-1.4067E-02	1.2740E+00	8.5000E-03
4.0000E-01	6.6420E-01	2.6480E-01	1.2800E-01	7.4299E-01	5.3797E-01	1.6311E+01	-2.5412E-02	1.2170E+00	8.5000E-03
5.0000E-01	7.5050E-01	2.8160E-01	1.0190E-01	6.3195E-01	4.8649E-01	2.3592E+01	-3.6757E-02	1.2480E+00	8.5000E-03
6.0000E-01	7.9000E-01	2.8760E-01	7.9600E-02	5.4020E-01	4.2657E-01	3.0874E+01	-4.8101E-02	1.1760E+00	8.5000E-03
7.0000E-01	8.1420E-01	2.5070E-01	6.0900E-02	4.7037E-01	3.7693E-01	3.8155E+01	-5.9446E-02	1.0700E+00	8.5000E-03
8.0000E-01	8.3830E-01	2.5640E-01	4.6800E-02	4.1735E-01	3.3949E-01	4.5437E+01	-7.0791E-02	9.6800E-01	8.5000E-03
9.0000E-01	8.6250E-01	2.1290E-01	3.9400E-02	3.7629E-01	3.1049E-01	5.2719E+01	-8.2135E-02	9.2900E-01	8.5000E-03
9.5000E-01	8.7050E-01	1.5280E-01	4.3200E-02	3.5914E-01	2.9597E-01	5.6359E+01	-8.7808E-02	9.1000E-01	8.5000E-03
1.0000E+00	8.7750E-01	0.	0.	3.4161E-01	2.8432E-01	6.0000E+01	-9.3480E-02	9.0100E-01	8.5000E-03

X	TANBI	TAN B	G	UT/2V	UA/2V	UCTSI	UCPSI	VR(M/SEC)	CAVV
1.7600E-01	1.3700E+00	8.0222E-01	0.	1.7274E-01	7.1783E-02	0.	0.	7.7590E+00	4.3336E+00
2.5000E-01	1.0269E+00	6.4031E-01	1.2538E-02	1.7074E-01	1.2101E-01	1.8382E-01	1.4329E-01	1.0635E+01	2.4179E+00
3.0000E-01	9.0493E-01	5.9666E-01	1.4997E-02	1.5990E-01	1.4076E-01	2.7574E-01	2.3106E-01	1.2757E+01	1.7021E+00
4.0000E-01	7.4415E-01	5.3797E-01	1.7399E-02	1.3222E-01	1.5517E-01	4.5241E-01	4.1565E-01	1.6967E+01	9.6563E-01
5.0000E-01	6.3294E-01	4.8649E-01	1.7723E-02	1.0737E-01	1.5905E-01	6.1078E-01	5.9662E-01	2.0942E+01	6.2310E-01
6.0000E-01	5.4105E-01	4.2657E-01	1.7992E-02	9.1360E-02	1.6731E-01	7.5963E-01	7.6116E-01	2.4709E+01	4.3978E-01
7.0000E-01	4.7090E-01	3.7683E-01	1.7775E-02	8.0215E-02	1.6527E-01	8.9750E-01	9.0230E-01	2.8392E+01	3.2514E-01
8.0000E-01	4.1901E-01	3.3949E-01	1.6611E-02	7.0367E-02	1.6459E-01	9.5547E-01	9.8725E-01	3.2107E+01	2.4784E-01
9.0000E-01	3.7688E-01	3.1048E-01	1.3474E-02	6.1267E-02	1.6137E-01	8.7954E-01	9.1990E-01	3.5846E+01	1.9361E-01
9.5000E-01	3.5870E-01	2.9687E-01	1.0228E-02	5.7852E-02	1.6156E-01	7.0561E-01	7.4217E-01	3.7704E+01	1.7260E-01
1.0000E+00	3.4215E-01	2.8432E-01	0.	5.4796E-02	1.5975E-01	0.	0.	3.9565E+01	1.5457E-01

CPTI=3.9996E-01 CPSI=5.0646E-01 ETAI=7.8773E-01 CTSI=5.0757E-01 CTSI/CPSI=1.0024E+00
CPT=3.8993E-01 CPS=5.5863E-01 ETA=6.9801E-01 CTS=4.9521E-01 CTS/CPS=8.8827E-01

X	CL	ALI(DEG)	FM/C	CD/CL	F(X)	LI(N/M)	TETS(DEG)	(C/RO)LE	(C/RO)TE	T/RO
1.760E-01	0.	0.	0.	0.	0.	0.	0.	-1.910E-01	1.910E-01	8.251E-02
2.500E-01	4.165E-01	6.414E-01	2.828E-02	2.041E-02	2.213E-01	3.720E+04	5.389E+00	-1.735E-01	2.657E-01	7.853E-02
3.000E-01	3.834E-01	5.904E-01	2.603E-02	2.217E-02	2.336E-01	5.337E+04	9.029E+00	-1.594E-01	3.174E-01	7.560E-02
4.000E-01	2.953E-01	4.547E-01	2.005E-02	2.879E-02	2.419E-01	8.393E+04	1.631E+01	-1.037E-01	4.253E-01	6.779E-02
5.000E-01	2.327E-01	3.594E-01	1.580E-02	3.653E-02	2.495E-01	1.037E+05	2.359E+01	-1.865E-02	5.445E-01	5.739E-02
6.000E-01	1.963E-01	3.023E-01	1.333E-02	4.330E-02	2.514E-01	1.239E+05	3.087E+01	9.347E-02	6.697E-01	4.579E-02
7.000E-01	1.730E-01	2.665E-01	1.175E-02	4.913E-02	2.565E-01	1.409E+05	3.816E+01	2.377E-01	7.991E-01	3.419E-02
8.000E-01	1.565E-01	2.411E-01	1.063E-02	5.430E-02	2.660E-01	1.499E+05	4.544E+01	4.234E-01	9.362E-01	2.430E-02
9.000E-01	1.437E-01	2.213E-01	9.759E-03	5.914E-02	2.779E-01	1.347E+05	5.272E+01	6.694E-01	1.07?E+00	1.599E-02
9.500E-01	1.377E-01	2.121E-01	9.352E-03	6.171E-02	2.817E-01	1.076E+05	5.636E+01	8.241E-01	1.132E+00	1.320E-02
1.000E+00	0.	0.	0.	0.	0.	0.	6.000E+01	1.089E+00	1.089E+00	0.

ETAD=7.4348E-01 PS(KW) =2.0818E+04 1-THO=8.3700E-01 1-WTT=7.8500E-01 V(KNOTS) =2.4071E+01 DESIGN TH(N) =1.4977E+06
Z= 6 N(REV/MIN)=1.0600E+02 AE/A0=7.6483E-01 V(M/SEC) =1.2347E+01 CALCULATED TH(N) =1.4977E+06

X	AREA(M2)	XBAR(M)	YBAR(M)	IXO(M4)	IYO(M4)	MXO(N-M)	MYO(N-M)	MTB(N-M)	MQB(N-M)	MAXSTRESS(PA)
1.760E-01	2.792E-01	6.333E-01	0.	1.373E-03	2.833E-02	3.128E+05	1.943E+06	4.328E+05	2.292E+05	4.728E+07
3.000E-01	3.187E-01	7.888E-01	3.101E-03	1.315E-03	5.016E-02	2.333E+05	1.335E+06	3.256E+05	1.669E+05	3.497E+07
4.000E-01	3.190E-01	8.740E-01	2.242E-03	1.055E-03	6.202E-02	1.521E+05	1.083E+06	2.442E+05	1.216E+05	2.927E+07
5.000E-01	2.863E-01	9.337E-01	1.592E-03	6.811E-04	6.315E-02	1.205E+05	5.912E+05	1.705E+05	9.235E+04	2.547E+07
6.000E-01	2.333E-01	9.576E-01	5.348E-04	3.532E-04	5.367E-02	7.265E+04	4.175E+05	1.076E+05	5.039E+04	2.542E+07
7.000E-01	1.700E-01	9.307E-01	0.	1.435E-04	3.726E-02	3.555E+04	2.500E+05	5.740E+04	2.609E+04	2.596E+07
8.000E-01	1.090E-01	8.501E-01	0.	4.535E-05	1.393E-02	1.352E+04	8.433E+04	2.326E+04	1.024E+04	2.484E+07

X	RAKG/D	PI XTANRI	PI XTANB
1.760E-01	0.	7.575E-01	4.436E-01
2.500E-01	-5.395E-03	8.066E-01	5.329E-01
3.000E-01	-1.437E-02	8.529E-01	5.623E-01
4.000E-01	-2.541E-02	9.351E-01	6.760E-01
5.000E-01	-3.675E-02	9.942E-01	7.642E-01
6.000E-01	-4.810E-02	1.020E+00	8.041E-01
7.000E-01	-5.945E-02	1.035E+00	8.287E-01
8.000E-01	-7.079E-02	1.051E+00	8.532E-01
9.000E-01	-8.214E-02	1.066E+00	8.779E-01
9.500E-01	-8.781E-02	1.071E+00	8.962E-01
1.000E+00	-9.348E-02	1.075E+00	8.932E-01

WEIGHT OF BLADES(N) = 273758.4944

WEIGHT OF PROP (BLADES + DESIGNATED HUB)(N) = 361222.8754

CENTER OF GRAVITY OF PROP REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= .021123

CENTER OF GRAVITY OF BLADES REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= .028651

HUB DIMENSIONS/D
LENGTH= .1957
FWD DIAM= .1912
AFT DIAM= .1630
MIDCHORD OF ROOT SECTION TO AFT END OF HUB= .0978
HUB DIAM AT MIDCHORD OF ROOT SECTION= .1760
FWD DIAM OF BORE= .1107
AFT DIAM OF BORE= .0844

KELLERS MINIMUM EAR= .7470E+00

SPEED COEFF V/(ND) JS= .9969E+00

ADVANCE COEFF V(1-WTT)/(ND) JA= .7826E+00

DESIGN THRUST COEFF KT= .1937E+00

TORQUE COEFF KQ= .3459E-01

PROPULSIVE EFFICIENCY ETAD= .7435E+00

BURRILL THRUST COEFF TC= .1414E+00

BURRILL CAVITATION COEFF SIGMA(0.7)= .3691E+00

CLEARANCE AT HUB BETWEEN BLADES/D= 4.7523E-02

CLEARANCE AT HUB BETWEEN FILLETS/D= 7.3561E-03

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MASS POLAR MOMENT OF INERTIA OF BLADES (KG-M2)=     .771877E+05

TOTAL MASS POLAR MOMENT OF INERTIA (KG-M2)=     .793262E+05

RADIUS OF GYRATION OF BLADE/D=     .2372

RADIUS OF GYRATION OF HUB/D=     .0698

TOTAL RADIUS OF GYRATION/D=     .2393


          ABS COEFFICIENTS (CALCULATED AT THE .25 RADIUS)

ABS MINIMUM THICKNESS IN INCHES (USING P/D INPUT)-
                 USING ABS RAKE = CONVENTIONAL RAKE,  T/D=  .2766E-01
                 USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D=  .3292E-01
VALUES USED IN DETERMINING THICKNESS-      A=  .123253E+02
                                           B=  .252902E+03
                                           C=  .146755E+05
SECTION AREA COEFFICIENT       CS=  .6942E+00

SECTION MODULUS COEFFICIENT      CN=  .8558E-01

AREA OF EXPANDED CYLINDRICAL SECTION IN SQ.METERS      AS= .2942E+00



FOR CN=.1
ABS MINIMUM THICKNESS IN INCHES (USING P/D INPUT)-
                 USING ABS RAKE = CONVENTIONAL RAKE,  T/D=  .2581E-01
                 USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D=  .3031E-01
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RADIAL PROPELLER DATA FOR INPUT INTO DESIGN PROGRAMS(8 RADIAL STRIPS ASSUMED)

YR	TAN BETA I	G	XSL(METERS)	XST(METERS)	1-WX	UA/2VS	THICKNESS(METERS)
.22750	1.10430	.1228E-01	-.62661	.85114	.47133	.1113E+00	.27947
.27900	.94978	.1426E-01	-.58011	1.03598	.52733	.1345E+00	.26952
.38200	.76777	.1689E-01	-.40629	1.42172	.64531	.1549E+00	.24327
.48500	.64902	.1767E-01	-.11610	1.84435	.74091	.1578E+00	.20781
.58800	.55092	.1797E-01	.27532	2.29050	.78656	.1618E+00	.16546
.69100	.47634	.1782E-01	.78244	2.75978	.81214	.1651E+00	.12335
.79400	.42078	.1672E-01	1.44032	3.25197	.83678	.1647E+00	.08609
.89700	.37832	.1357E-01	2.31576	3.74934	.86194	.1614E+00	.05632
.94850	.35923	.1040E-01	2.96950	3.95737	.87029	.1636E+00	.04688
1.00000			3.81951	3.81961			

SISI CASE 8

THRUST OPTION, DENSITY OF PROP(KG/M3)= 7750.3717

V(M/SEC) 1.2099E+01 1.2347E+01 1.2604E+01 1.2727E+01 1.2961E+01
PE(KW) 1.4414E+04 1.5478E+04 1.6589E+04 1.7193E+04 1.8103E+04

D(M) = 7.0104 ,1-WTT=.7850 ,1-THD=.8370 ,H(M) = 15.5496 ,RHO(KG/M3) = 1025.8615

Z 6
AE/AC 7.6483E-01 7.6800E-01
N(REV/MIN) 1.0600E+02

X INPUT	1-WX INPUT	C/D INPUT	T/C INPUT	TANBI INPUT	TANB INPUT	TETS(DEG) LINEAR	RAKG/D LINEAR	P/D INPUT	CD INPUT
1.7500E-01	4.3550E-01	1.9100E-01	2.1600E-01	1.3700E+00	8.0222E-01	0.	0.	1.3400E+00	8.5000E-03
2.5000E-01	4.9410E-01	2.1950E-01	1.7550E-01	1.0259E+00	6.4031E-01	5.3593E+00	-8.3950E-03	1.3250E+00	8.5000E-03
3.0000E-01	5.5250E-01	2.3790E-01	1.5890E-01	9.0493E-01	5.9665E-01	9.0291E+00	-1.4067E-02	1.2740E+00	8.5000E-03
4.0000E-01	6.6420E-01	2.6480E-01	1.2900E-01	7.4415E-01	5.3797E-01	1.6311E+01	-2.5412E-02	1.2730E+00	8.5000E-03
5.0000E-01	7.5050E-01	2.9160E-01	1.0190E-01	6.3294E-01	4.8649E-01	2.3592E+01	-3.6757E-02	1.2490E+00	8.5000E-03
6.0000E-01	7.9000E-01	2.8760E-01	7.9600E-02	5.4105E-01	4.2657E-01	3.0874E+01	-4.8101E-02	1.1760E+00	8.5000E-03
7.0000E-01	8.1420E-01	2.5730E-01	6.0900E-02	4.7090E-01	3.7693E-01	3.8155E+01	-5.9446E-02	1.0700E+00	8.5000E-03
8.0000E-01	8.3830E-01	2.5640E-01	4.6800E-02	4.1831E-01	3.3949E-01	4.5437E+01	-7.0791E-02	9.6800E-01	8.5000E-03
9.0000E-01	8.6250E-01	2.2290E-01	3.5400E-02	3.7699E-01	3.1049E-01	5.2719E+01	-8.2135E-02	9.2500E-01	8.5000E-03
9.5000E-01	8.7050E-01	1.5260E-01	4.3200E-02	3.5870E-01	2.9697E-01	5.6359E+01	-8.7808E-02	9.1000E-01	8.5000E-03
1.0000E+00	8.7750E-01	0.	0.	3.4215E-01	2.9432E-01	6.0200E+01	-9.3490E-02	9.0100E-01	8.5000E-03

X	TANBI	TAN B	G	UT/2V	UA/2V	DCTSI	DCPSI	VP(M/SEC)	CAVV
1.7600E-01	1.3721E+00	8.0222E-01	0.	1.7331E-01	7.1770E-02	0.	0.	7.9162E+00	4.1603E+00
2.5000E-01	1.0285E+00	6.4031E-01	1.2592E-02	1.7143E-01	1.2323E-01	1.8139E-01	1.4396E-01	1.0852E+01	2.3211E+00
3.0000E-01	9.0629E-01	5.9666E-01	1.5070E-02	1.6063E-01	1.4113E-01	2.7681E-01	2.3230E-01	1.3019E+01	1.6338E+00
4.0000E-01	7.4527E-01	5.3797E-01	1.7201E-02	1.3299E-01	1.5682E-01	4.5479E-01	4.1847E-01	1.7317E+01	9.2685E-01
5.0000E-01	6.3389E-01	4.8649E-01	1.7848E-02	1.0814E-01	1.5994E-01	6.1474E-01	6.0139E-01	2.1417E+01	5.9804E-01
6.0000E-01	5.4186E-01	4.2657E-01	1.8122E-02	9.2587E-02	1.6335E-01	7.6521E-01	7.6791E-01	2.5222E+01	4.2207E-01
7.0000E-01	4.7151E-01	3.7693E-01	1.7922E-02	8.0595E-02	1.6443E-01	8.9454E-01	9.1133E-01	2.8981E+01	3.1204E-01
8.0000E-01	4.1863E-01	3.3949E-01	1.6754E-02	7.3721E-02	1.6593E-01	9.6448E-01	9.9702E-01	3.2774E+01	2.3785E-01
9.0000E-01	3.7745E-01	3.1048E-01	1.3595E-02	6.1559E-02	1.6259E-01	8.8618E-01	9.2920E-01	3.6591E+01	1.8580E-01
9.5000E-01	3.5924E-01	2.9687E-01	1.0320E-02	5.8424E-02	1.6190E-01	7.1181E-01	7.4982E-01	3.8498E+01	1.6564E-01
1.0000E+00	3.4266E-01	2.8432E-01	0.	5.5349E-02	1.6112E-01	0.	0.	4.0387E+01	1.4833E-01

CPTI=4.0197E-01 CPSI=5.1102E-01 ETAI=7.8661E-01 CTSI=5.1143E-01 CTSI/CPSI=1.0008E+00
CPT=3.9294E-01 CPS=5.6316E-01 ETA=6.9773E-01 CTS=4.9996E-01 CTS/CPS=8.8776E-01

X	CL	ALI(DEG)	FM/C	CD/CL	F(X)	LI(N/M)	TETS(DEG)	(C/RD)LE	(C/RD)TE	T/RD
1.760E-01	0.	0.	0.	0.	0.	0.	0.	-1.910E-01	1.913E-01	8.251E-02
2.500E-01	4.184E-01	6.444E-01	2.841E-02	2.031E-02	2.215E-01	3.891E+04	5.383E+00	-1.735E-01	2.657E-01	7.853E-02
3.000E-01	3.853E-01	5.934E-01	2.615E-02	2.206E-02	2.338E-01	5.597E+04	9.029E+00	-1.584E-01	3.174E-01	7.560E-02
4.000E-01	2.971E-01	4.575E-01	2.017E-02	2.861E-02	2.421E-01	9.482E+04	1.631E+01	-1.037E-01	4.253E-01	6.779E-02
5.000E-01	2.344E-01	3.609E-01	1.591E-02	3.627E-02	2.497E-01	1.388E+05	2.359E+01	-1.865E-02	5.445E-01	5.739E-02
6.000E-01	1.978E-01	3.047E-01	1.343E-02	4.296E-02	2.516E-01	1.302E+05	3.087E+01	9.347E-02	6.687E-01	4.579E-02
7.000E-01	1.745E-01	2.687E-01	1.185E-02	4.872E-02	2.567E-01	1.479E+05	3.816E+01	2.377E-01	7.991E-01	3.419E-02
8.000E-01	1.579E-01	2.432E-01	1.072E-02	5.383E-02	2.661E-01	1.564E+05	4.544E+01	4.234E-01	9.362E-01	2.400E-02
9.000E-01	1.450E-01	2.233E-01	9.845E-03	5.862E-02	2.790E-01	1.417E+05	5.272E+01	6.684E-01	1.074E+00	1.599E-02
9.500E-01	1.390E-01	2.140E-01	9.435E-03	6.116E-02	2.818E-01	1.131E+05	5.636E+01	8.241E-01	1.133E+00	1.320E-02
1.000E+00	0.	0.	0.	0.	0.	0.	6.000E+01	1.069E+00	1.093E+00	0.

ETAO=7.4306E-01 PS(KW) =2.2325E+04 1-THD=8.3700E-01 1-WTT=7.8500E-01 V(KNOTS) =2.4500E+01 DESIGN TH(N) =1.5725E+06
Z= 6 N(REV/MIN)=1.0600E+02 AE/AC=7.6483E-01 V(M/SEC) =1.2604E+01 CALCULATED TH(N) =1.5725E+06

X	AREA(M2)	XBAR(M)	YBAR(M)	IXO(M4)	IYO(M4)	MXO(N-M)	MYO(N-M)	MTB(N-M)	MOB(N-M)	MAXSTRESS(PA)
1.760E-01	2.792E-01	6.333E-01	0.	1.373E-03	2.833E-02	3.319E+05	1.959E+06	4.546E+05	2.408E+05	4.971E+07
3.000E-01	3.187E-01	7.888E-01	3.120E-03	1.315E-03	5.316E-02	2.499E+05	1.343E+06	3.421E+05	1.754E+05	3.694E+07
4.000E-01	3.160E-01	8.780E-01	2.257E-03	1.055E-03	6.202E-02	1.653E+05	1.087E+06	2.566E+05	1.278E+05	3.095E+07
5.000E-01	2.863E-01	9.337E-01	1.606E-03	6.811E-04	6.315E-02	1.303E+05	5.934E+05	1.792E+05	9.655E+04	2.697E+07
6.000E-01	2.333E-01	9.536E-01	8.423E-04	3.532E-04	5.367E-02	7.869E+04	4.182E+05	1.131E+05	5.296E+04	2.681E+07
7.000E-01	1.700E-01	9.327E-01	0.	1.435E-04	3.726E-02	3.977E+04	2.501E+05	6.034E+04	2.743E+04	2.726E+07
8.000E-01	1.030E-01	8.501E-01	0.	4.535E-05	1.993E-02	1.482E+04	8.427E+04	2.445E+04	1.077E+04	2.624E+07

X	RAKG/D	PI XTANBI	PI XTANB
1.760E-01	0.	7.586E-01	4.436E-01
2.500E-01	-8.395E-03	8.078E-01	5.029E-01
3.000E-01	-1.407E-02	8.542E-01	5.623E-01
4.000E-01	-2.541E-02	9.365E-01	6.763E-01
5.000E-01	-3.676E-02	9.957E-01	7.642E-01
6.000E-01	-4.813E-02	1.021E+00	8.041E-01
7.000E-01	-5.945E-02	1.037E+00	8.287E-01
8.000E-01	-7.079E-02	1.052E+00	8.532E-01
9.000E-01	-8.214E-02	1.067E+00	8.779E-01
9.500E-01	-8.781E-02	1.072E+00	8.860E-01
1.000E+00	-9.348E-02	1.077E+00	8.932E-01

WEIGHT OF BLADES(N) = 273758.4944

WEIGHT OF PROP (BLADES + DESIGNATED HUB)(N) = 351222.8754

CENTER OF GRAVITY OF PROP REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= .021118

CENTER OF GRAVITY OF BLADES REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= .026635

HUB DIMENSIONS/D
LENGTH= .1957
FWD DIAM= .1912
AFT DIAM= .1630
MIDCHORD OF ROOT SECTION TO AFT END OF HUB= .0978
HUB DIAM AT MIDCHORD OF ROOT SECTION= .1760
FWD DIAM OF BORE= .1307
AFT DIAM OF BORE= .0844

KELLERS MINIMUM EAR= .7770E+00

SPEED COEFF V/(ND) JS= .1018E+01

ADVANCE COEFF V(1-WTT)/(ND) JA= .7999E+00

DESIGN THRUST COEFF KT= .2033E+00

TORQUE COEFF KQ= .3710E-01

PROPULSIVE EFFICIENCY ETAD= .7431E+00

BURRILL THRUST COEFF TC= .1478E+00

BURRILL CAVITATION COEFF SIGMA(0.7)= .3673E+00

CLEARANCE AT HUB BETWEEN BLADES/D= 4.7523E-02

CLEARANCE AT HUB BETWEEN FILLETS/D= 7.3561E-03

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MASS POLAR MOMENT OF INERTIA OF BLADES (KG-M2)=    .771877E+05

TOTAL MASS POLAR MOMENT OF INERTIA (KG-M2)=    .793252E+05

RADIUS OF GYRATION OF BLADE/D=    .2372

RADIUS OF GYRATION OF HUB/D=    .0599

TOTAL RADIUS OF GYRATION/D=    .2393


        ABS COEFFICIENTS (CALCULATED AT THE .25 RADIUS)

ABS MINIMUM THICKNESS IN INCHES (USING P/D INPUT)-
                    USING ABS RAKE = CONVENTIONAL RAKE.  T/D=  .2876E-01
                    USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE.  T/D=  .3402E-01

VALUES USED IN DETERMINING THICKNESS-      A=  .123059E+02
                                           B=  .252902E+03
                                           C=  .145355E+05

SECTION AREA COEFFICIENT     CS=  .5942E+00

SECTION MODULUS COEFFICIENT     CN=  .8558E-01

AREA OF EXPANDED CYLINDRICAL SECTION IN SQ.METERS     AS= .2942E+00



FOR CN=.1
ABS MINIMUM THICKNESS IN INCHES (USING P/D INPUT)-
                    USING ABS RAKE = CONVENTIONAL RAKE.  T/D=  .2603E-01
                    USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE.  T/D=  .3133E-01
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RADIAL PROPELLER DATA FOR INPUT INTO DESIGN PROGRAMS(8 RADIAL STRIPS ASSUMED)

XR	TAN BETA I	G	XSL(METERS)	XST(METERS)	1-WX	UA/2VS	THICKNESS(METERS)
.22750	1.10596	.1032E-01	-.62661	.85114	.47103	.1114E+00	.27947
.27900	.95121	.1433E-01	-.58011	1.07598	.52733	.1348E+00	.26952
.39200	.76892	.1699E-01	-.40629	1.47272	.64531	.1555E+00	.24327
.48530	.64399	.1779E-01	-.11610	1.84495	.74991	.1596E+00	.20701
.59800	.55175	.1811E-01	.27502	2.29950	.79556	.1628E+00	.16546
.69130	.47705	.1797E-01	.78244	2.75879	.81214	.1563E+00	.12335
.79450	.42142	.1695E-01	1.44332	3.25197	.83678	.1660E+00	.08609
.89730	.37859	.1369E-01	2.31576	3.74934	.86194	.1628E+00	.05632
.94350	.35977	.1049E-01	2.86853	3.95737	.87029	.1619E+00	.04688
1.00000			3.81851	3.81861			

SISI CASE 8

THRUST OPTION, DENSITY OF PROP(KG/M3)= 7750.3717

V(M/SEC) 1.2089E+01 1.2347E+01 1.2604E+01 1.2707E+01 1.2961E+01
PE(KW) 1.4414E+04 1.5478E+04 1.6589E+04 1.7199E+04 1.8103E+04

D(M) = 7.0104 ,1-WTT=.7850 ,1-THD=.8370 ,H(M) = 15.8496 ,RHO(KG/M3) = 1025.8615

Z 6
AE/A0 7.6483E-01 7.6800E-01
N(REV/MIN) 1.0600E+02

X INPUT	1-WX INPUT	C/D INPUT	T/C INPUT	TANBI INPUT	TANB INPUT	TETS(DEG) LINEAR	RAKG/D LINEAR	P/D INPUT	CD INPUT
1.7600E-01	4.3580E-01	1.9100E-01	2.1600E-01	1.3721E+00	8.0222E-01	0.	0.	1.3400E+00	8.5000E-03
2.5000E-01	4.9410E-01	2.1960E-01	1.7880E-01	1.0285E+00	6.4031E-01	5.3983E+00	-8.3950E-03	1.3250E+00	8.5000E-03
3.0000E-01	5.5250E-01	2.3790E-01	1.5590E-01	9.0629E-01	5.9666E-01	9.0291E+00	-1.4067E-02	1.2740E+00	8.5000E-03
4.0000E-01	6.6420E-01	2.6490E-01	1.2800E-01	7.4527E-01	5.3797E-01	1.6311E+01	-2.5412E-02	1.2570E+00	8.5000E-03
5.0000E-01	7.5080E-01	2.8160E-01	1.0190E-01	6.3369E-01	4.8649E-01	2.3592E+01	-3.6757E-02	1.2480E+00	8.5000E-03
6.0000E-01	7.9900E-01	2.8760E-01	7.9600E-02	5.4136E-01	4.2657E-01	3.0874E+01	-4.8101E-02	1.1760E+00	8.5000E-03
7.0000E-01	8.1420E-01	2.8270E-01	6.0920E-02	4.7151E-01	3.7683E-01	3.8155E+01	-5.9446E-02	1.0700E+00	8.5000E-03
8.0000E-01	8.3830E-01	2.5640E-01	4.6800E-02	4.1853E-01	3.3949E-01	4.5437E+01	-7.0791E-02	9.6800E-01	8.5000E-03
9.0000E-01	8.6250E-01	2.2290E-01	3.9400E-02	3.7745E-01	3.1048E-01	5.2719E+01	-8.2135E-02	9.2500E-01	8.5000E-03
9.5000E-01	8.7050E-01	1.5250E-01	4.3200E-02	3.5924E-01	2.9697E-01	5.6359E+01	-8.7808E-02	9.1000E-01	8.5000E-03
1.0000E+00	8.7760E-01	0.	0.	3.4266E-01	2.8432E-01	6.0000E+01	-9.3480E-02	9.0100E-01	8.5000E-03

X	TANBI	TAN B	G	UT/2V	UA/2V	DCTSI	DCPSI	VR(M/SEC)	CAVV
1.7600E-01	1.3751E+00	8.0222E-01	0.	1.7415E-01	7.1753E-02	0.	0.	7.9744E+00	4.0955E+00
2.5000E-01	1.0308E+00	6.4031E-01	1.2672E-02	1.7246E-01	1.2355E-01	1.8224E-01	1.4496E-01	1.0935E+01	2.2848E+00
3.0000E-01	9.0933E-01	5.9666E-01	1.5179E-02	1.6174E-01	1.4169E-01	2.7841E-01	2.3417E-01	1.3119E+01	1.6082E+00
4.0000E-01	7.4595E-01	5.3797E-01	1.7354E-02	1.3416E-01	1.5780E-01	4.5836E-01	4.2270E-01	1.7454E+01	9.1217E-01
5.0000E-01	6.3532E-01	4.8649E-01	1.8035E-02	1.0929E-01	1.6326E-01	6.2069E-01	5.0858E-01	2.1588E+01	5.8852E-01
6.0000E-01	5.4309E-01	4.2657E-01	1.8332E-02	9.3679E-02	1.6409E-01	7.7359E-01	7.7836E-01	2.5425E+01	4.1533E-01
7.0000E-01	4.7257E-01	3.7683E-01	1.8142E-02	8.1917E-02	1.6915E-01	9.0511E-01	9.2417E-01	2.9215E+01	3.0705E-01
8.0000E-01	4.1958E-01	3.3949E-01	1.6970E-02	7.1655E-02	1.6769E-01	9.7651E-01	1.0117E+00	3.3040E+01	2.3404E-01
9.0000E-01	3.7830E-01	3.1048E-01	1.3775E-02	6.2749E-02	1.6455E-01	8.9765E-01	9.4334E-01	3.6888E+01	1.9282E-01
9.5000E-01	3.6005E-01	2.9697E-01	1.0458E-02	5.9284E-02	1.6391E-01	7.2112E-01	7.6133E-01	3.8801E+01	1.6298E-01
1.0000E+00	3.4343E-01	2.8432E-01	0.	5.6180E-02	1.6317E-01	0.	0.	4.0716E+01	1.4595E-01

CPTI=4.0650E-01 CPSI=5.1787E-01 ETAI=7.8493E-01 CTSI=5.1736E-01 CTSI/CPSI=9.9843E-01
CPT=3.9744E-01 CPS=5.6999E-01 ETA=6.9729E-01 CTS=5.0557E-01 CTS/CPS=8.8698E-01

X	CL	ALI(DEG)	FM/C	CD/CL	F(X)	LI(N/M)	TETS(DEG)	(C/RO)LE	(C/RO)TE	T/RO
1.760E-01	0.	0.	0.	0.	0.	0.	0.	-1.910E-01	1.910E-01	8.251E-02
2.500E-01	4.213E-01	6.459E-01	2.861E-02	2.017E-02	2.218E-01	3.979E+04	5.388E+00	-1.735E-01	2.657E-01	7.853E-02
3.000E-01	3.883E-01	5.980E-01	2.636E-02	2.189E-02	2.341E-01	5.717E+04	9.029E+00	-1.584E-01	3.174E-01	7.560E-02
4.000E-01	2.998E-01	4.617E-01	2.036E-02	2.835E-02	2.425E-01	8.696E+04	1.631E+01	-1.037E-01	4.259E-01	6.779E-02
5.000E-01	2.369E-01	3.648E-01	1.609E-02	3.589E-02	2.490E-01	1.118E+05	2.359E+01	-1.865E-02	5.445E-01	5.739E-02
6.000E-01	2.002E-01	3.082E-01	1.359E-02	4.247E-02	2.519E-01	1.338E+05	3.087E+01	9.347E-02	6.637E-01	4.579E-02
7.000E-01	1.766E-01	2.720E-01	1.199E-02	4.812E-02	2.570E-01	1.522E+05	3.816E+01	2.377E-01	7.991E-01	3.419E-02
8.000E-01	1.599E-01	2.463E-01	1.086E-02	5.315E-02	2.664E-01	1.610E+05	4.544E+01	4.234E-01	9.362E-01	2.400E-02
9.000E-01	1.469E-01	2.263E-01	9.977E-03	5.785E-02	2.732E-01	1.479E+05	5.272E+01	6.684E-01	1.074E+00	1.599E-02
9.500E-01	1.408E-01	2.169E-01	9.563E-03	6.035E-02	2.820E-01	1.165E+05	5.636E+01	8.241E-01	1.130E+00	1.320E-02
1.000E+00	0.	0.	0.	0.	0.	0.	6.000E+01	1.089E+00	1.089E+00	0.

ETAD=7.4241E-01 PS(KW) =2.3154E+04 1-THD=8.3700E-01 1-WTT=7.8500E-01 V(KNOTS) =2.4700E+01 DESIGN TH(N) =1.6162E+06
Z= 6 N(REV/MIN)=1.0600E+02 AE/AO=7.6483E-01 V(M/SEC) =1.2707E+01 CALCULATED TH(N) =1.6162E+06

X	AREA(M2)	YBAR(M)	YBAR(M)	IXO(M4)	IYO(M4)	MXO(N-M)	MYO(N-M)	MTB(N-M)	MQB(N-M)	MAXSTRESS(PA)
1.760E-01	2.792E-01	6.333E-01	0.	1.373E-03	2.833E-02	3.433E+05	1.968E+06	4.677E+05	2.478E+05	5.117E+07
3.000E-01	3.187E-01	7.888E-01	3.149E-03	1.315E-03	5.016E-02	2.599E+05	1.348E+06	3.519E+05	1.805E+05	3.812E+07
4.000E-01	3.190E-01	[illegible]	2.283E-03	1.055E-03	5.232E-02	1.732E+05	1.090E+06	2.640E+05	1.316E+05	3.196E+07
5.000E-01	2.853E-01	9.337E-01	1.627E-03	6.811E-04	6.315E-02	1.757E+05	5.946E+05	1.945E+05	8.911E+04	2.797E+07
6.000E-01	2.333E-01	9.536E-01	5.535E-04	3.532E-04	5.367E-02	8.234E+04	4.186E+05	1.164E+05	5.453E+04	2.765E+07
7.000E-01	1.703E-01	9.327E-01	0.	1.435E-04	3.726E-02	4.174E+04	2.501E+05	6.213E+04	2.824E+04	2.804E+07
8.000E-01	1.093E-01	8.561E-01	0.	4.535E-05	1.993E-02	1.562E+04	8.424E+04	2.518E+04	1.109E+04	2.709E+07

X	PAKS/D	PI YTANBI	PI XTANB
1.760E-01	0.	7.603E-01	4.436E-01
2.500E-01	-8.395E-03	9.096E-01	5.029E-01
3.000E-01	-1.407E-02	9.561E-01	5.623E-01
4.000E-01	-2.541E-02	9.366E-01	5.760E-01
5.000E-01	-3.676E-02	9.980E-01	7.542E-01
6.000E-01	-4.810E-02	1.024E+00	8.041E-01
7.000E-01	-5.945E-02	1.039E+00	8.287E-01
8.000E-01	-7.079E-02	1.055E+00	8.532E-01
9.000E-01	-8.214E-02	1.070E+00	8.779E-01
9.500E-01	-8.791E-02	1.075E+00	8.850E-01
1.000E+00	-9.348E-02	1.079E+00	8.932E-01

WEIGHT OF BLADES(N) = 273758.4944

WEIGHT OF PROP (BLADES + DESIGNATED HUB)(N) = 361222.8754

CENTER OF GRAVITY OF PROP REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= .021091

CENTER OF GRAVITY OF BLADES REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= .028609

HUB DIMENSIONS/D
LENGTH= .1957
FWD DIAM= .1812
AFT DIAM= .1630
MIDCHORD OF ROOT SECTION TO AFT END OF HUB= .0978
HUB DIAM AT MIDCHORD OF ROOT SECTION= .1768
FWD DIAM OF BORE= .1107
AFT DIAM OF BORE= .0944

KELLERS MINIMUM EAR= .7946E+00

SPEED COEFF V/(ND) JS= .1026E+01

ADVANCE COEFF V(1-WTT)/(ND) JA= .8054E+00

DESIGN THRUST COEFF KT= .2090E+00

TORQUE COEFF KQ= .3847E-01

PROPULSIVE EFFICIENCY ETAD= .7424E+00

BURRILL THRUST COEFF TC= .1517E+00

BURRILL CAVITATION COEFF SIGMA(0.7)= .3665E+00

CLEARANCE AT HUB BETWEEN BLADES/D= 4.7523E-02

CLEARANCE AT HUB BETWEEN FILLETS/D= 7.3561E-03

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MASS POLAR MOMENT OF INERTIA OF BLADES (KG-M2)=   .771877E+05

TOTAL MASS POLAR MOMENT OF INERTIA (KG-M2)=    .793262E+05

RADIUS OF GYRATION OF BLADE/D=    .2372

RADIUS OF GYRATION OF HUB/D=    .0639

TOTAL RADIUS OF GYRATION/D=    .2093


        ABS COEFFICIENTS (CALCULATED AT THE .25 RADIUS)

ABS MINIMUM THICKNESS IN INCHES (USING P/D INPUT)-
                  USING ABS RAKE = CONVENTIONAL RAKE,  T/D=  .2934E-01
                  USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D=  .3461E-01

VALUES USED IN DETERMINING THICKNESS-     A=  .123050E+02
                                          B=  .252902E+03
                                          C=  .146355E+05

SECTION AREA COEFFICIENT     CS=  .6942E+00

SECTION MODULUS COEFFICIENT     CN=  .8558E-01

AREA OF EXPANDED CYLINDRICAL SECTION IN SQ.METERS     AS= .2942E+00



FOR CN=.1
ABS MINIMUM THICKNESS IN INCHES (USING P/D INPUT)-
                  USING ABS RAKE = CONVENTIONAL RAKE,  T/D=  .2737E-01
                  USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D=  .3188E-01
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RADIAL PROPELLER DATA FOR INPUT INTO DESIGN PROGRAMS(8 RADIAL STRIPS ASSUMED)

XP	TAN BETA I	G	XSL(METERS)	XST(METERS)	1-WX	UA/2VS	THICKNESS(METERS)
.22750	1.13845	.1038E-01	-.62661	.85114	.47103	.1116E+00	.27947
.27900	.95335	.1443E-01	-.58011	1.07598	.52733	.1353E+00	.26952
.38200	.77065	.1713E-01	-.40629	1.42172	.64531	.1564E+00	.24327
.48500	.65045	.1797E-01	-.11010	1.84495	.74091	.1599E+00	.20701
.58800	.55299	.1832E-01	.27502	2.29050	.78656	.1644E+00	.16546
.69100	.47812	.1819E-01	.78244	2.75978	.81214	.1690E+00	.12335
.79400	.42236	.1708E-01	1.44032	3.25187	.83579	.1578E+00	.08609
.89700	.37344	.1387E-01	2.31576	3.74974	.86194	.1647E+00	.05632
.94850	.36058	.1063E-01	2.86950	3.95737	.87029	.1639E+00	.04688
1.00000			3.81861	3.81861			

SISI CASE 8

THRUST OPTION, DENSITY OF PROP(KG/M3)= 7750.3717

V(M/SEC)	1.2089E+01	1.2347E+01	1.2604E+01	1.2707E+01	1.2861E+01
PE(KW)	1.4414E+04	1.5478E+04	1.6589E+04	1.7190E+04	1.8103E+04

D(M) = 7.0104 ,1-WTT=.7850 ,1-THO=.8370 ,H(M) = 15.8496 ,RHO(KG/M3) = 1025.8615

Z	6	
AE/A0	7.6483E-01	7.6800E-01
N(REV/MIN)	1.0600E+02	

X INPUT	1-WX INPUT	C/D INPUT	T/C INPUT	TANBI INPUT	TANB INPUT	TETS(DEG) LINEAR	RAKG/D LINEAR	P/D INPUT	CD INPUT
1.7600E-01	4.3580E-01	1.9100E-01	2.1600E-01	1.3751E+00	8.0222E-01	0.	0.	1.3400E+00	8.5000E-03
2.5000E-01	4.9410E-01	2.1960E-01	1.7880E-01	1.0305E+00	6.4031E-01	5.3883E+00	-8.3950E-03	1.3250E+00	8.5000E-03
3.0000E-01	5.5250E-01	2.3790E-01	1.5890E-01	9.0833E-01	5.9666E-01	9.0291E+00	-1.4067E-02	1.2740E+00	8.5000E-03
4.0000E-01	6.6420E-01	2.6480E-01	1.2800E-01	7.4695E-01	5.3797E-01	1.6311E+01	-2.5412E-02	1.2570E+00	8.5000E-03
5.0000E-01	7.5080E-01	2.8160E-01	1.0190E-01	6.3532E-01	4.8649E-01	2.3592E+01	-3.6757E-02	1.2480E+00	8.5000E-03
6.0000E-01	7.9000E-01	2.8760E-01	7.9500E-02	5.4318E-01	4.2657E-01	3.0874E+01	-4.8101E-02	1.1760E+00	8.5000E-03
7.0000E-01	8.1420E-01	2.5070E-01	6.0900E-02	4.7257E-01	3.7693E-01	3.8155E+01	-5.9446E-02	1.0700E+00	8.5000E-03
8.0000E-01	8.3830E-01	2.5640E-01	4.6800E-02	4.1958E-01	3.3949E-01	4.5437E+01	-7.0791E-02	9.6800E-01	8.5000E-03
9.0000E-01	8.6250E-01	2.0290E-01	3.9400E-02	3.7630E-01	3.1048E-01	5.2719E+01	-8.2135E-02	9.2500E-01	8.5000E-03
9.5000E-01	8.7050E-01	1.5280E-01	4.3200E-02	3.6005E-01	2.9687E-01	5.6359E+01	-8.7808E-02	9.1000E-01	8.5300E-03
1.0000E+00	8.7760E-01	0.	0.	3.4343E-01	2.8432E-01	6.0000E+01	-9.3480E-02	9.0100E-01	8.5000E-03

X	TANBI	TAN B	G	UT/2V	UA/2V	DCTSI	DCPSI	VR(M/SEC)	CAVV
1.7600E-01	1.3795E+00	8.0222E-01	0.	1.7534E-01	7.1727E-02	0.	0.	8.0618E+00	4.0013E+00
2.5000E-01	1.0341E+00	6.4031E-01	1.2787E-02	1.7391E-01	1.2402E-01	1.8343E-01	1.463[illegible]E-01	1.1059E+01	2.2321E+00
3.0000E-01	9.1122E-01	5.9666E-01	1.5333E-02	1.6333E-01	1.4248E-01	2.8066E-01	2.3682E-01	1.3270E+01	1.5709E+00
4.0000E-01	7.4932E-01	5.3797E-01	1.7572E-02	1.3580E-01	1.5919E-01	4.6340E-01	4.2871E-01	1.7659E+01	8.9087E-01
5.0000E-01	6.3734E-01	4.8649E-01	1.8300E-02	1.1091E-01	1.6211E-01	6.2910E-01	6.1879E-01	2.1845E+01	5.7470E-01
6.0000E-01	5.4491E-01	4.2657E-01	1.8629E-02	9.5229E-02	1.6709E-01	7.8545E-01	7.9250E-01	2.5729E+01	4.0555E-01
7.0000E-01	4.7407E-01	3.7683E-01	1.8455E-02	8.3369E-02	1.7059E-01	9.2008E-01	9.4245E-01	2.9566E+01	2.9980E-01
8.0000E-01	4.2091E-01	3.3949E-01	1.7276E-02	7.3009E-02	1.7332E-01	9.9355E-01	1.0326E+00	3.3437E+01	2.2850E-01
9.0000E-01	3.7950E-01	3.1048E-01	1.4031E-02	6.4014E-02	1.6745E-01	9.1390E-01	9.6347E-01	3.7333E+01	1.7849E-01
9.5000E-01	3.6119E-01	2.9687E-01	1.0654E-02	6.0505E-02	1.6675E-01	7.3432E-01	7.7773E-01	3.9269E+01	1.5912E-01
1.0000E+00	3.4453E-01	2.8432E-01	0.	5.7362E-02	1.6607E-01	0.	0.	4.1207E+01	1.4249E-01

CPTI=4.1290E-01	CPSI=5.2763E-01	ETAI=7.8256E-01	CTSI=5.2504E-01	CTSI/CPSI=9.9509E-01
CPT=4.0383E-01	CPS=5.7970E-01	ETA=6.9662E-01	CTS=5.1353E-01	CTS/CPS=8.8584E-01

X	CL	ALI(DEG)	FM/C	CD/CL	F(X)	LI(N/M)	TETS(DEG)	(C/RO)LE	(C/RO)TE	T/RO
1.760E-01	0.	0.	0.	0.	0.	0.	0.	-1.910E-01	1.910E-01	8.251E-02
2.500E-01	4.255E-01	6.552E-01	2.883E-02	1.998E-02	2.223E-01	4.109E+04	5.388E+00	-1.735E-01	2.657E-01	7.853E-02
3.000E-01	3.925E-01	6.044E-01	2.665E-02	2.166E-02	2.346E-01	5.912E+04	9.029E+00	-1.584E-01	3.174E-01	7.560E-02
4.000E-01	3.036E-01	4.676E-01	2.062E-02	2.799E-02	2.429E-01	9.017E+04	1.631E+01	-1.037E-01	4.259E-01	6.779E-02
5.000E-01	2.404E-01	3.702E-01	1.632E-02	3.536E-02	2.494E-01	1.152E+05	2.359E+01	-1.865E-02	5.445E-01	5.739E-02
6.000E-01	2.034E-01	3.133E-01	1.381E-02	4.178E-02	2.523E-01	1.393E+05	3.087E+01	9.347E-02	6.687E-01	4.579E-02
7.000E-01	1.797E-01	2.767E-01	1.220E-02	4.730E-02	2.574E-01	1.595E+05	3.816E+01	2.377E-01	7.991E-01	3.419E-02
8.000E-01	1.628E-01	2.508E-01	1.106E-02	5.220E-02	2.667E-01	1.573E+05	4.544E+01	4.234E-01	9.362E-01	2.460E-02
9.000E-01	1.497E-01	2.305E-01	1.016E-02	5.679E-02	2.784E-01	1.522E+05	5.272E+01	6.684E-01	1.074E+00	1.599E-02
9.500E-01	1.435E-01	2.210E-01	9.743E-03	5.924E-02	2.822E-01	1.216E+05	5.636E+01	8.241E-01	1.130E+00	1.320E-02
1.000E+00	0.	0.	0.	0.	0.	0.	6.000E+01	1.089E+00	1.083E+00	0.

ETAD=7.4145E-01	PS(KW) =2.4416E+04	1-THD=8.3700E-01	1-WTT=7.8500E-01	V(KNOTS) =2.5000E+01	DESIGN TH(N) =1.6817E+06
Z= 6	N(REV/MIN)=1.0600E+02		AE/A0=7.6483E-01	V(M/SEC) =1.2861E+01	CALCULATED TH(N) =1.6817E+06

X	AREA(M2)	XBAR(M)	YBAR(M)	IXO(M4)	IYO(M4)	MXO(N-M)	MYO(N-M)	MTB(N-M)	MQB(N-M)	MAXSTRESS(PA)
1.760E-01	2.792E-01	6.333E-01	0.	1.373E-03	2.833E-02	3.633E+05	1.982E+06	4.871E+05	2.587E+05	5.334E+07
3.000E-01	3.187E-01	7.889E-01	3.159E-03	1.315E-03	5.016E-02	2.749E+05	1.356E+06	3.667E+05	1.881E+05	3.989E+07
4.000E-01	3.180E-01	8.750E-01	2.321E-03	1.055E-03	6.222E-02	1.851E+05	1.094E+06	2.752E+05	1.372E+05	3.348E+07
5.000E-01	2.863E-01	9.377E-01	1.656E-03	6.811E-04	6.215E-02	1.442E+05	5.965E+05	1.923E+05	9.294E+04	2.922E+07
6.000E-01	2.333E-01	9.536E-01	8.697E-04	3.532E-04	5.367E-02	8.782E+04	4.193E+05	1.214E+05	5.688E+04	2.892E+07
7.000E-01	1.700E-01	9.307E-01	0.	1.435E-04	3.726E-02	4.459E+04	2.502E+05	6.481E+04	2.946E+04	2.922E+07
8.000E-01	1.090E-01	8.501E-01	0.	4.535E-05	1.993E-02	1.631E+04	8.418E+04	2.627E+04	1.157E+04	2.836E+07

X	RAKG/D	PI XTANBI	PI XTANB
1.760E-01	0.	7.628E-01	4.436E-01
2.500E-01	-8.395E-03	8.122E-01	5.329E-01
3.000E-01	-1.407E-02	8.598E-01	5.623E-01
4.000E-01	-2.541E-02	9.416E-01	6.762E-01
5.000E-01	-3.676E-02	1.001E+00	7.542E-01
6.000E-01	-4.810E-02	1.027E+00	8.041E-01
7.000E-01	-5.945E-02	1.043E+00	8.287E-01
8.000E-01	-7.079E-02	1.058E+00	8.532E-01
9.000E-01	-8.214E-02	1.073E+00	8.779E-01
9.500E-01	-8.781E-02	1.078E+00	8.860E-01
1.000E+00	-9.348E-02	1.082E+00	8.932E-01

WEIGHT OF BLADES(N) = 273758.4944

WEIGHT OF PROP (BLADES + DESIGNATED HUB)(N) = 361222.8754

CENTER OF GRAVITY OF PROP REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= .821864

CENTER OF GRAVITY OF BLADES REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= .828574

HUB DIMENSIONS/D
LENGTH= .1957
FWD DIAM= .1812
AFT DIAM= .1538
MIDCHORD OF ROOT SECTION TO AFT END OF HUB= .0978
HUB DIAM AT MIDCHORD OF ROOT SECTION= .1760
FWD DIAM OF BORE= .1307
AFT DIAM OF BORE= .0844

KELLERS MINIMUM EAR= .8208E+00

SPEED COEFF V/(ND) JS= .1034E+01

ADVANCE COEFF V(1-WTT)/(ND) JA= .8152E+00

DESIGN THRUST COEFF KT= .2175E+00

TORQUE COEFF KQ= .4057E-01

PROPULSIVE EFFICIENCY ETAD= .7415E+00

BURRILL THRUST COEFF TC= .1575E+00

BURRILL CAVITATION COEFF SIGMA(0.7)= .3654E+00

CLEARANCE AT HUB BETWEEN BLADES/D= 4.7523E-02

CLEARANCE AT HUB BETWEEN FILLETS/D= 7.3561E-03

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MASS POLAR MOMENT OF INERTIA OF BLADES (KG-M2)=    .771877E+05

TOTAL MASS POLAR MOMENT OF INERTIA (KG-M2)=   .793262E+05

RADIUS OF GYRATION OF BLADE/D=    .2372

RADIUS OF GYRATION OF HUB/D=    .0698

TOTAL RADIUS OF GYRATION/D=    .2093


          ABS COEFFICIENTS (CALCULATED AT THE .25 RADIUS)

ABS MINIMUM THICKNESS IN INCHES (USING P/D INPUT)-
                    USING ABS RAKE = CONVENTIONAL RAKE,  T/D=  .3022E-01
                    USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D=  .3548E-01

VALUES USED IN DETERMINING THICKNESS-     A=  .123050E+02
                                          B=  .252902E+03
                                          C=  .146355E+05

SECTION AREA COEFFICIENT     CS=  .6942E+00

SECTION MODULUS COEFFICIENT     CN=  .8558E-01

AREA OF EXPANDED CYLINDRICAL SECTION IN SQ.METERS     AS= .2942E+00


FOR CN=.1
ABS MINIMUM THICKNESS IN INCHES (USING P/D INPUT)-
                    USING ABS RAKE = CONVENTIONAL RAKE,  T/D=  .2818E-01
                    USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D=  .3269E-01
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RADIAL PROPELLER DATA FOR INPUT INTO DESIGN PROGRAMS(8 RADIAL STRIPS ASSUMED)

XR	TAN BETA I	G	XSL(METERS)	XST(METERS)	1-WX	UA/2VS	THICKNESS(METERS)
.22750	1.11197	.1047E-01	-.62651	.85114	.47103	.1119E+00	.27947
.27900	.95638	.1457E-01	-.58011	1.03598	.52733	.1359E+00	.26952
.34200	.77310	.1734E-01	-.40629	1.47172	.64531	.1577E+00	.24327
.48500	.65252	.1823E-01	-.11610	1.84495	.74091	.1617E+00	.20701
.58800	.55475	.1861E-01	.27532	2.29050	.78656	.1665E+00	.16546
.69100	.47965	.1853E-01	.78244	2.75878	.81214	.1704E+00	.12335
.79400	.42371	.1739E-01	1.44032	3.25197	.83678	.1704E+00	.08609
.89700	.38265	.1413E-01	2.31576	3.74934	.86194	.1675E+00	.05632
.94850	.36172	.1093E-01	2.86953	3.95737	.87029	.1668E+00	.04688
1.00000			3.81951	3.81861			

APPENDIX E

SAMPLE DESIGN USING POWER OPTION

OPTIONS EXERCISED IN APPENDIX E

Power or thrust	Power
Calculations with input $\tan\beta_I$	N/A
$\tan\beta_I$ (Lerbs or Input)	Lerbs
$\tan\beta$ (calculated from $(1-w_x)$ or input)	Calc
C_D (constant, variable, or calculated)	Calc
Multiple RPM	Yes
Multiple Z	Yes
Multiple AE/AO	Yes
Check AE/AO of input C/D and modify	Yes
SKEW (Linear/nonlinear)	NL
RAKE (Linear/nonlinear)	NL
P/D (input or approximated by $\pi x \tan\beta_I$)	Approx Calc
ABS Coefficients	Yes
Hub Geometry	Approx Calc
Input Units	English
Output Units	English

AML GENERAL PURPOSE 80 COLUMN SHEET

NDW-NSRDC-5230/7 (979)

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11
DOCUMENTATION CASE A
30000 11 0 -1 .01 0 0 4 0
23 .785 .837 52 0 0
5 23.5 24 24.5 24.7 25 19329 20756 22246 23052 24277
2 6 5 3 0 .768 .9 2 106 120
.176 .25 .3 .4 .5 .6 .7 .8 .9 .95 1.
.4358 .4941 .5525 .6642 .7508 .79 .8142 .8383 .8625 .8705 .8776
0 0 0 0 0 0 0 0 0 0 0
.191 .2196 .2379 .2648 .2816 .2876 .2807 .2564 .2029 .1528 0
.216 .1788 .1589 .128 .1019 .0796 .0609 .0468 .0394 .0432 0
0 -3.2 -4.011 0 10.313 21.658 32.716 44.977 54.546 57.754 60
0 0 0 -.107826 -.100435 -.576087 -.846087 -1.05 -1.152174 -1.14 -1.121739
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REMARKS

DOCUMENTATION CASE A

PS(HP)= 3.0000E+04, DENSITY OF PROP(LBM/FT3)= 483.9400

V(KNOTS)	2.3500E+01	2.4000E+01	2.4500E+01	2.4700E+01	2.5000E+01
PE(HP)	1.9329E+04	2.0756E+04	2.2246E+04	2.3052E+04	2.4277E+04

D(FT)= 23.0000 ,1-WTT=.7850 ,1-THD=.8370 ,H(FT)= 52.0000 ,RHO(SLUG/FT3)= 1.9905

Z	6 5		
AE/AO	7.6483E-01	7.6800E-01	9.0000E-01
N(REV/MIN)	1.0600E+02	1.2000E+02	

X INPUT	1-HX INPUT	C/D INPUT	T/C INPUT	TANBI LEPBS	TANB CALCULATED	TETS(DEG) NONLINEAR	RAKG/D NONLINEAR	P/D PIXTANBI	CD CALCULATED
1.7600E-01	4.3560E-01	1.9100E-01	2.1500E-01	1.2665E+00	8.0210E-01	0.	0.	0.	1.2337E-02
2.5000E-01	4.9410E-01	2.1950E-01	1.7880E-01	9.4938E-01	6.4022E-01	-3.2000E+00	0.	0.	1.0810E-02
3.0000E-01	5.5250E-01	2.3790E-01	1.5590E-01	9.3660E-01	5.9658E-01	-4.0110E+00	0.	0.	1.0227E-02
4.0000E-01	6.6420E-01	2.6480E-01	1.2800E-01	6.8796E-01	5.3789E-01	0.	-1.0783E-01	0.	9.5484E-03
5.0000E-01	7.5090E-01	2.8160E-01	1.0190E-01	5.8514E-01	4.8642E-01	1.0313E+01	-1.0344E-01	0.	9.1268E-03
6.0000E-01	7.9900E-01	2.8760E-01	7.9620E-02	5.0019E-01	4.2651E-01	2.1658E+01	-5.7609E-01	0.	8.8361E-03
7.0000E-01	8.1420E-01	2.8570E-01	6.0900E-02	4.3529E-01	3.7678E-01	3.2716E+01	-8.4609E-01	0.	8.6228E-03
8.0000E-01	8.3830E-01	2.5640E-01	4.6800E-02	3.8644E-01	3.3944E-01	4.4977E+01	-1.0500E+00	0.	8.4728E-03
9.0000E-01	8.6250E-01	2.0290E-01	3.9400E-02	3.4842E-01	3.1044E-01	5.4546E+01	-1.1522E+00	0.	8.3964E-03
9.5000E-01	8.7050E-01	1.5280E-01	4.3200E-02	3.3161E-01	2.9682E-01	5.7754E+01	-1.1400E+00	0.	8.4355E-03
1.0000E+00	8.7760E-01	0.	0.	3.1631E-01	2.8429E-01	6.0000E+01	-1.1217E+00	0.	9.0000E-03

X	TANBI	TAN B	G	UT/2V	UA/2V	DCTSI	DCPSI	VP(FT/SEC)	CAVV
1.7600E-01	1.3720E+00	8.0210E-01	0.	1.7337E-01	7.1781E-02	0.	0.	2.5972E+01	4.1597E+00
2.5000E-01	1.0285E+00	6.4022E-01	1.2597E-02	1.7151E-01	1.2327E-01	1.9148E-01	1.4405E-01	3.5607E+01	2.3207E+00
3.0000E-01	9.0531E-01	5.9658E-01	1.5078E-02	1.6071E-01	1.4129E-01	2.7697E-01	2.3248E-01	4.2715E+01	1.6336E+00
4.0000E-01	7.4529E-01	5.3789E-01	1.7212E-02	1.3309E-01	1.5692E-01	4.5512E-01	4.1885E-01	5.6819E+01	9.2667E-01
5.0000E-01	6.3391E-01	4.8642E-01	1.7861E-02	1.0822E-01	1.5905E-01	6.1526E-01	6.0200E-01	7.0272E+01	5.9792E-01
6.0000E-01	5.4187E-01	4.2651E-01	1.8136E-02	9.2656E-02	1.6347E-01	7.6508E-01	7.6869E-01	8.2756E+01	4.2199E-01
7.0000E-01	4.7152E-01	3.7678E-01	1.7936E-02	8.0960E-02	1.6566E-01	8.9536E-01	9.1231E-01	9.5091E+01	3.1198E-01
8.0000E-01	4.1564E-01	3.3944E-01	1.6769E-02	7.0763E-02	1.6598E-01	9.6544E-01	9.9817E-01	1.0754E+02	2.3779E-01
9.0000E-01	3.7746E-01	3.1044E-01	1.3607E-02	6.1920E-02	1.6284E-01	9.8712E-01	9.3034E-01	1.2006E+02	1.8576E-01
9.5000E-01	3.5925E-01	2.9682E-01	1.0330E-02	5.9483E-02	1.6225E-01	7.1259E-01	7.5076E-01	1.2629E+02	1.6560E-01
1.0000E+00	3.4267E-01	2.8428E-01	0.	5.5404E-02	1.6127E-01	0.	0.	1.3252E+02	1.4830E-01

CPTI=4.0234E-01 CPSI=5.1157E-01 ETAI=7.8649E-01 CTSI=5.1199E-01 CTSI/CPSI=1.0036E+00
CPT=3.9301E-01 CPS=5.6449E-01 ETA=6.9622E-01 CTS=4.9996E-01 CTS/CPS=8.8569E-01

X	CL	ALI(DEG)	FM/C	CD/CL	F(X)	LI(LBF/FT)	TETS(DEG)	(C/RD)LE	(C/RD)TE	T/RD
1.760E-01	0.	0.	0.	0.	0.	0.	0.	-1.910E-01	1.910E-01	8.251E-02
2.500E-01	4.186E-01	6.446E-01	2.842E-02	2.583E-02	2.215E-01	2.569E+03	-3.200E+00	-2.396E-01	1.996E-01	7.853E-02
3.000E-01	3.855E-01	5.937E-01	2.618E-02	2.653E-02	2.338E-01	3.930E+03	-4.011E+00	-2.662E-01	2.096E-01	7.560E-02
4.000E-01	2.972E-01	4.577E-01	2.019E-02	3.213E-02	2.422E-01	5.916E+03	0.	-2.648E-01	2.643E-01	6.779E-02
5.000E-01	2.345E-01	3.611E-01	1.592E-02	3.892E-02	2.497E-01	7.455E+03	1.031E+01	-1.750E-01	3.882E-01	5.739E-02
6.000E-01	1.980E-01	3.049E-01	1.344E-02	4.463E-02	2.516E-01	9.926E+03	2.166E+01	-2.964E-02	5.455E-01	4.579E-02
7.000E-01	1.746E-01	2.689E-01	1.185E-02	4.939E-02	2.567E-01	1.014E+04	3.272E+01	1.612E-01	7.226E-01	3.419E-02
8.000E-01	1.580E-01	2.433E-01	1.073E-02	5.362E-02	2.661E-01	1.072E+04	4.498E+01	4.244E-01	9.372E-01	2.400E-02
9.000E-01	1.451E-01	2.235E-01	9.854E-03	5.786E-02	2.780E-01	9.716E+03	5.455E+01	7.129E-01	1.119E+00	1.599E-02
9.500E-01	1.391E-01	2.142E-01	9.444E-03	6.065E-02	2.819E-01	7.759E+03	5.775E+01	8.647E-01	1.170E+00	1.320E-02
1.000E+00	0.	0.	0.	0.	0.	0.	6.000E+01	1.107E+00	1.107E+00	0.

ETAO=7.4133E-01 PS(HP) =3.0008E+04 1-THD=8.3700E-01 1-WTT=7.8500E-01 V(KNOTS) =2.4500E+01 DESIGN TH(LBF)=3.5350E+05
Z= 6 N(REV/MIN)=1.0600E+02 AE/AO=7.6483E-01 V(FT/SEC) =4.1351E+01 CALCULATED TH(LBF)=3.5350E+05

X	AREA (IN2)	YBAR (IN)	YBAR (IN)	IXO (IN4)	IYO (IN4)	MXO (IN-LBF)	MYO (IN-LBF)	MTB (IN-LBF)	MOB (IN-LBF)	MAXSTRESS (LBF/IN2)
1.760E-01	4.328E+02	2.493E+01	0.	3.299E+03	6.807E+04	1.294E+05	1.325E+06	4.026E+06	2.135E+06	3.721E+03
3.000E-01	4.939E+02	3.125E+01	1.229E-01	3.160E+03	1.225E+05	-6.693E+05	5.199E+06	3.030E+06	1.554E+06	3.423E+03
4.000E-01	4.979E+02	3.457E+01	8.892E-02	2.576E+03	1.490E+05	-1.556E+07	-3.470E+06	2.273E+06	1.132E+06	5.362E+03
5.000E-01	4.439E+02	3.676E+01	6.327E-02	1.636E+03	1.517E+05	-1.149E+07	-2.052E+06	1.559E+06	7.667E+05	2.576E+04
6.000E-01	3.516E+02	3.754E+01	3.319E-02	8.486E+02	1.299E+05	-1.751E+07	-2.594E+06	1.002E+06	4.690E+05	3.093E+04
7.000E-01	2.635E+02	3.664E+01	0.	3.448E+02	8.952E+04	-4.291E+06	5.792E+05	5.347E+05	2.428E+05	5.063E+03
8.000E-01	1.690E+02	3.347E+01	0.	1.089E+02	6.799E+04	-1.146E+06	2.919E+05	2.167E+05	9.524E+04	1.478E+04

X	RAKG/D	PI XTANPI	PI XTANP
1.760E-01	0.	7.596E-01	4.435E-01
2.500E-01	0.	8.079E-01	5.029E-01
3.000E-01	0.	8.542E-01	5.623E-01
4.000E-01	-1.078E-01	9.366E-01	6.759E-01
5.000E-01	-1.004E-01	9.957E-01	7.641E-01
6.000E-01	-5.761E-01	1.021E+00	8.040E-01
7.000E-01	-8.461E-01	1.037E+00	8.286E-01
8.000E-01	-1.059E+00	1.052E+00	8.531E-01
9.000E-01	-1.157E+00	1.067E+00	8.777E-01
9.500E-01	-1.140E+00	1.072E+00	8.859E-01
1.000E+00	-1.122E+00	1.077E+00	8.931E-01

WEIGHT OF BLADES(LBF)= 61543.3524

WEIGHT OF PROP (BLADES + CYLINDRICAL HUB)(LBF)= 96749.8881

CENTER OF GRAVITY OF PROP REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD. + AFT)/D= -.207136

CENTER OF GRAVITY OF BLADES REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD. + AFT)/D= -.291973

HUB DIMENSIONS/D   HUB DIAM = .1769
HUB LENGTH = .1769
MIDCHORD OF ROOT SECTION TO AFT END OF HUB = .0888

KELLERS MINIMUM EAR= .7770E+00

SPEED COEFF V/(ND) JS= .1319E+01

ADVANCE COEFF V(1-WTT)/(ND) JA= .7999E+00

DESIGN THRUST COEFF KT= .2033E+00

TORQUE COEFF KQ= .3718E-01

PROPULSIVE EFFICIENCY ETAD= .7413E+00

BURRILL THRUST COEFF TC= .1479E+00

BURRILL CAVITATION COEFF SIGMA(0.7)= .3673E+00

CLEARANCE AT HUB BETWEEN BLADES/D= 4.1102E-02

CLEARANCE AT HUB BETWEEN FILLETS/D= -4.8438E-03

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MASS POLAR MOMENT OF INERTIA OF BLADES (LBM-IN2)=  .263763E+09

TOTAL MASS POLAR MOMENT OF INERTIA (LBM-IN2)=  .263763E+09

RADIUS OF GYRATION OF BLADE/D=     .2372

RADIUS OF GYRATION OF HUB/D=    0.0000

TOTAL RADIUS OF GYRATION/D=     .1995


        ABS COEFFICIENTS (CALCULATED AT THE .25 RADIUS)

ABS MINIMUM THICKNESS IN INCHES (USING P/D=PIXTANBI)-
                  USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.1906E-01
                  USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.1906E-01

VALUES USED IN DETERMINING THICKNESS-      A=  .102598E+02
                                           B=  .252902E+03
                                           C=  .109347E+05

SECTION AREA COEFFICIENT      CS=  .69425E+00

SECTION MODULUS COEFFICIENT      CN=  .8558E-01

AREA OF EXPANDED CYLINDRICAL SECTION IN SQ.INCHES      AS= .4559E+03



FOR CN=.1
ABS MINIMUM THICKNESS IN INCHES (USING P/D=PIXTANBI)-
                  USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.1395E-01
                  USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.1395E-01
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RADIAL PROPELLER DATA FOR INPUT INTO DESIGN PROGRAMS(8 RADIAL STRIPS ASSUMED)

XR	TAN BETA I	G	XSL(INCHES)	XST(INCHES)	1-WX	UA/2VS	THICKNESS(INCHES)
.22750	1.10595	.1032E-01	-30.99926	27.17974	.47103	.1114E+00	11.00267
.27900	.95122	.1434E-01	-35.41377	28.29798	.52733	.1349E+00	10.61108
.38200	.76894	.1700E-01	-37.49397	34.49812	.64531	.1556E+00	9.57751
.49500	.64901	.1790E-01	-26.57959	50.63843	.74091	.1588E+00	8.15008
.59800	.55176	.1812E-01	-6.80973	72.53958	.79556	.1629E+00	5.51410
.69100	.47706	.1799E-01	19.45000	97.25846	.81214	.1664E+00	4.85646
.79400	.42142	.1697E-01	56.25706	127.57819	.83678	.1661E+00	3.33921
.89700	.37560	.1371E-01	97.26563	153.70597	.86194	.1629E+00	2.21752
.94850	.35977	.1050E-01	118.58704	161.45577	.87029	.1621E+00	1.84558
1.00000			152.76260	152.76260			

DOCUMENTATION CASE A

PS(HP)= 3.0000E+04, DENSITY OF PROP(LBM/FT3)= 483.8400

V(KNOTS)	2.3500E+01	2.4000E+01	2.4500E+01	2.4700E+01	2.5000E+01
PE(HP)	1.9329E+04	2.0756E+04	2.2246E+04	2.3152E+04	2.4777E+04

D(FT)= 23.0000 ,1-WTT=.7850 ,1-THD=.8370 ,H(FT)= 52.0000 ,RHO(SLUG/FT3)= 1.9905

7 6 5
AE/AO 7.6483E-01 7.6800E-01 9.0000E-01
N(REV/MIN) 1.0600E+02 1.2000E+02

X INPUT	1-HX INPUT	C/D INPUT	T/C INPUT	TANBI LERBS	TANB CALCULATED	TETS(DEG) NONLINEAR	RAKG/D NONLINEAR	P/D PIXTANBI	CD CALCULATED
1.7600E-01	4.3583E-01	1.9100E-01	2.1600E-01	1.1197E+00	7.0552E-01	0.	0.	0.	1.2337E-02
2.5000E-01	4.9410E-01	2.1960E-01	1.7880E-01	8.3862E-01	5.6553E-01	-3.2000E+00	0.	0.	1.0810E-02
3.0000E-01	5.5250E-01	2.3790E-01	1.5890E-01	7.3899E-01	5.2598E-01	-4.0110E+00	0.	0.	1.0227E-02
4.0000E-01	6.6420E-01	2.6480E-01	1.2800E-01	6.0769E-01	4.7514E-01	0.	-1.0783E-01	0.	9.5484E-03
5.0000E-01	7.5080E-01	2.8150E-01	1.0190E-01	5.1698E-01	4.2967E-01	1.0313E+01	-1.0044E-01	0.	9.1268E-03
6.0000E-01	7.9000E-01	2.8760E-01	7.9600E-02	4.4183E-01	3.7575E-01	2.1658E+01	-5.7609E-01	0.	8.8361E-03
7.0000E-01	8.1420E-01	2.8070E-01	6.0900E-02	3.8447E-01	3.3292E-01	3.2716E+01	-8.4609E-01	0.	8.6228E-03
8.0000E-01	8.7830E-01	2.5640E-01	4.6800E-02	3.4135E-01	2.9984E-01	4.4977E+01	-1.0500E+00	0.	8.4728E-03
9.0000E-01	8.6250E-01	2.0290E-01	3.9400E-02	3.0777E-01	2.7422E-01	5.4546E+01	-1.1522E+00	0.	8.3964E-03
9.5000E-01	8.7050E-01	1.5280E-01	4.3200E-02	2.9292E-01	2.6220E-01	5.7754E+01	-1.1400E+00	0.	8.4355E-03
1.0000E+00	8.7760E-01	0.	0.	2.7941E-01	2.5112E-01	6.0000E+01	-1.1217E+00	0.	8.0000E-03

X	TANBI	TAN B	G	UT/2V	UA/2V	DCTSI	DCPSI	VP(FT/SEC)	CAVV
1.7600E-01	1.1915E+00	7.0272E-01	0.	1.7506E-01	9.0985E-02	0.	0.	2.8256E+01	3.5534E+00
2.5000E-01	8.8565E-01	5.6600E-01	1.2129E-02	1.6473E-01	1.4319E-01	2.0848E-01	1.6265E-01	3.9236E+01	1.9278E+00
3.0000E-01	7.8044E-01	5.2266E-01	1.4159E-02	1.5049E-01	1.5505E-01	3.0908E-01	2.5417E-01	4.7165E+01	1.3485E+00
4.0000E-01	6.4178E-01	4.7124E-01	1.5487E-02	1.1932E-01	1.6379E-01	4.7953E-01	4.3377E-01	6.2871E+01	7.5929E-01
5.0000E-01	5.4587E-01	4.2615E-01	1.5539E-02	9.3604E-02	1.5983E-01	6.2214E-01	5.9832E-01	7.7947E+01	4.8668E-01
6.0000E-01	4.6562E-01	3.7367E-01	1.5445E-02	7.9140E-02	1.6205E-01	7.5471E-01	7.4453E-01	9.2147E+01	3.4063E-01
7.0000E-01	4.0604E-01	3.3010E-01	1.5111E-02	6.7039E-02	1.6000E-01	8.7024E-01	8.7155E-01	1.0621E+02	2.5018E-01
8.0000E-01	3.6050E-01	2.9738E-01	1.4106E-02	5.7696E-02	1.5712E-01	9.3490E-01	9.4996E-01	1.2038E+02	1.8982E-01
9.0000E-01	3.2504E-01	2.7197E-01	1.1536E-02	4.9794E-02	1.5210E-01	9.6473E-01	8.9084E-01	1.3461E+02	1.4779E-01
9.5000E-01	3.0936E-01	2.6005E-01	8.0191E-03	4.6783E-02	1.5059E-01	6.9851E-01	7.2345E-01	1.4170E+02	1.3155E-01
1.0000E+00	2.9508E-01	2.4906E-01	0.	4.4110E-02	1.4915E-01	0.	1.	1.4879E+02	1.1765E-01

CPTI=3.9899E-01 CPSI=4.9971E-01 ETAT=7.9845E-01 CTSI=5.0997E-01 CTSI/CPSI=1.0205E+00
CPT=3.8853E-01 CPS=5.7822E-01 ETA=6.7195E-01 CTS=4.9560E-01 CTS/CPS=8.5885E-01

X	CL	ALI(DEG)	FM/C	CD/CL	F(X)	LT(LBF/FT)	TETS(DEG)	(C/RO)LE	(C/RO)TE	T/RO
1.760E-01	0.	0.	0.	0.	0.	0.	0.	-1.910E-01	1.910E-01	8.251E-02
2.500E-01	3.628E-01	5.586E-01	2.463E-02	2.980E-02	2.102E-01	2.807E+03	-3.200E+00	-2.383E-01	2.009E-01	7.853E-02
3.000E-01	3.252E-01	5.008E-01	2.209E-02	3.145E-02	2.204E-01	3.939E+03	-4.011E+00	-2.645E-01	2.113E-01	7.560E-02
4.000E-01	2.397E-01	3.692E-01	1.629E-02	3.983E-02	2.256E-01	5.743E+03	0.	-2.648E-01	2.648E-01	6.779E-02
5.000E-01	1.824E-01	2.809E-01	1.239E-02	5.003E-02	2.301E-01	7.145E+03	1.031E+01	-1.791E-01	3.841E-01	5.739E-02
6.000E-01	1.502E-01	2.313E-01	1.020E-02	5.884E-02	2.319E-01	9.395E+03	2.166E+01	-3.732E-02	5.379E-01	4.579E-02
7.000E-01	1.306E-01	2.011E-01	8.869E-03	6.602E-02	2.369E-01	9.468E+03	3.272E+01	1.577E-01	7.121E-01	3.419E-02
8.000E-01	1.179E-01	1.814E-01	7.997E-03	7.194E-02	2.474E-01	1.032E+04	4.498E+01	4.112E-01	9.240E-01	2.400E-02
9.000E-01	1.088E-01	1.676E-01	7.390E-03	7.715E-02	2.621E-01	9.165E+03	5.455E+01	6.980E-01	1.104E+00	1.599E-02
9.500E-01	1.050E-01	1.616E-01	7.127E-03	8.037E-02	2.680E-01	7.371E+03	5.775E+01	8.496E-01	1.155E+00	1.320E-02
1.000E+00	0.	0.	0.	0.	0.	0.	6.000E+01	1.092E+00	1.092E+00	0.

ETAD=7.1886E-01 PS(HP) =2.9989E+04 1-THD=8.3700E-01 1-WTT=7.8500E-01 V(KNOTS) =2.4299E+01 DESIGN TH(LBF)=3.4540E+05
Z= 6 N(REV/MIN)=1.2000E+02 AE/AO=7.6483E-01 V(FT/SEC) =4.1012E+01 CALCULATED TH(LBF)=3.4540E+05

X	AREA (IN2)	XBAR (IN)	YBAR (IN)	IXO (IN4)	IYO (IN4)	MXO (IN-LBF)	MYO (IN-LBF)	MTQ (IN-LBF)	MOB (IN-LBF)	MAXSTRESS (LBF/IN2)
.750E-01	4.328E+02	2.493E+01	0.	3.298E+03	6.937E+04	-1.637[illegible]E+06	7.339E+05	3.880E+06	1.880E+06	4.792E+03
[illegible].000E-01	4.939E+02	3.105E+01	9.913E-02	3.160E+03	1.235E+05	-2.265[illegible]E+06	7.214E+06	2.907E+06	1.364E+06	4.502E+03
[illegible].000E-01	4.929E+02	3.457E+01	6.745E-02	2.536E+03	1.492E+05	-2.327[illegible]E+07	-3.559E+06	2.175E+06	9.929E+05	6.707E+03
[illegible].000E-01	4.438E+02	3.676E+01	4.716E-02	1.636E+03	1.517E+05	-1.597[illegible]E+07	-1.922E+06	1.516E+06	6.727E+05	3.496E+04
5.000E-01	3.615E+02	3.754E+01	2.505E-02	8.486E+02	1.299E+05	-1.729[illegible]E+07	-2.489E+06	9.561E+05	4.124E+05	4.107E+04
7.000E-01	2.635E+02	3.664E+01	0.	3.448E+02	8.952E+04	-5.799[illegible]E+06	9.826E+05	5.106E+05	2.144E+05	4.773E+03
8.000E-01	1.690E+02	3.347E+01	0.	1.089E+02	4.799E+04	-1.593[illegible]E+06	4.387E+05	2.074E+05	8.464E+04	1.911E+04

X	RAKG/D	PI XTANRI	PI XTANR
1.760E-01	0.	6.533E-01	3.385E-01
2.500E-01	0.	6.956E-01	4.405E-01
3.000E-01	0.	7.356E-01	4.926E-01
4.000E-01	-1.078E-01	8.065E-01	5.922E-01
5.000E-01	-1.004E-01	8.575E-01	6.694E-01
6.000E-01	-5.761E-01	8.795E-01	7.043E-01
7.000E-01	-3.461E-01	8.929E-01	7.259E-01
8.000E-01	-1.050E+00	9.060E-01	7.474E-01
9.000E-01	-1.152E+00	9.190E-01	7.690E-01
9.500E-01	-1.140E+00	9.233E-01	7.761E-01
1.000E+00	-1.122E+00	9.270E-01	7.824E-01

WEIGHT OF BLADES(LBF)= 61543.3524

WEIGHT OF PROP (BLADES + CYLINDRICAL HUB)(LBF)= 86749.8881

CENTER OF GRAVITY OF PROP REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD. + AFT)/D= -.289980

CENTER OF GRAVITY OF BLADES REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD. + AFT)/D= -.295983

HUB DIMENSIONS/D HUB DIAM = .1767
HUB LENGTH = .1769
MIDCHORD OF ROOT SECTION TO AFT END OF HUB = .0880

KELLERS MINIMUM EAR= .7615E+00

SPEED COEFF V/(ND) JS= .8916E+00

ADVANCE COEFF V(1-WTT)/(ND) JA= .6999E+00

DESIGN THRUST COEFF KT= .1550E+00

TORQUE COEFF KQ= .2561E-01

PROPULSIVE EFFICIENCY ETAD= .7189E+00

BURRILL THRUST COEFF TC= .1116E+00

BURRILL CAVITATION COEFF SIGMA(C.7)= .2951E+00

CLEARANCE AT HUB BETWEEN BLADES/D= 3.8104E-02

CLEARANCE AT HUB BETWEEN FILLETS/D= -1.2541E-02

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MASS POLAR MOMENT OF INERTIA OF BLADES (LBM-IN2)=  .263763E+09

TOTAL MASS POLAR MOMENT OF INERTIA (LBM-IN2)=  .263763E+09

RADIUS OF GYRATION OF BLADE/D=    .2372

RADIUS OF GYRATION OF HUB/D=   0.0000

TOTAL RADIUS OF GYRATION/D=    .1998


          ABS COEFFICIENTS (CALCULATED AT THE .25 RADIUS)

ABS MINIMUM THICKNESS IN INCHES (USING P/D=PIXTANBI)-
                    USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.4049E-01
                    USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.4049E-01

VALUES USED IN DETERMINING THICKNESS-     A=  .107106E+02
                                          B=  .324119E+03
                                          C=  .985485E+04

SECTION AREA COEFFICIENT     CS=  .6942E+00

SECTION MODULUS COEFFICIENT     CN=  .8558E-01

AREA OF EXPANDED CYLINDRICAL SECTION IN SQ.INCHES     AS= .4559E+03


FOR CN=.1
ABS MINIMUM THICKNESS IN INCHES (USING P/D=PIXTANBI)-
                    USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.3228E-01
                    USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.3228E-01
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RADIAL PROPELLER DATA FOR INPUT INTO DESIGN PROGRAMS(8 RADIAL STRIPS ASSUMED)

XR	TAN BETA I	G	XSL(INCHES)	XST(INCHES)	1-WX	UA/2VS	THICKNESS(INCHES)
.22750	.95236	.1004E-01	-30.85698	27.32291	.47103	.1293E+00	11.00267
.27930	.81912	.1362E-01	-35.18566	29.47595	.52733	.1501E+00	10.61108
.38230	.66215	.1541E-01	-37.40843	34.54256	.64531	.1637E+00	9.57751
.48530	.55887	.1555E-01	-27.04817	50.15995	.74091	.1633E+00	8.15008
.58830	.47513	.1546E-01	-7.91546	71.53395	.78656	.1600E+00	5.51410
.69100	.41081	.1516E-01	18.03405	95.44751	.81714	.1602E+00	4.55646
.79400	.36790	.1419E-01	54.44790	125.75033	.83478	.1574E+00	3.38921
.89700	.32602	.1161E-01	95.21578	151.65599	.86194	.1522E+00	2.21752
.94850	.33981	.8961E-02	116.49761	159.36635	.87029	.1536E+00	1.84558
1.00000			150.67366	150.67366			

DOCUMENTATION CASE A

PS(HP)= 3.0000E+04, DENSITY OF PROP(LBM/FT3)= 483.8400

V(KNOTS)	2.3500E+01	2.4000E+01	2.4500E+01	2.4700E+01	2.5000E+01
PE(HP)	1.9329E+04	2.0756E+04	2.2246E+04	2.3052E+04	2.4277E+04

D(FT)= 23.0000 ,1-WTT=.7850 ,1-THO=.8370 ,H(FT)= 52.0000 ,RHO(SLUG/FT3)= 1.9905

Z	6 5		
AE/AO	7.6483E-01	7.6500E-01	9.0000E-01
N(REV/MIN)	1.0600E+02	1.2000E+02	

X INPUT	1-RX INPUT	C/D ADJUSTED	T/C INPUT	TANBI LERBS	TANB CALCULATED	TETS(DEG) NONLINEAR	RAKG/D NONLINEAR	P/D PIXTANBI	CD CALCULATED
1.7600E-01	4.3580E-01	2.2476E-01	2.1600E-01	1.2665E+00	8.3210E-01	0.	0.	0.	1.2337E-02
2.5000E-01	4.9410E-01	2.5841E-01	1.7880E-01	9.4938E-01	6.4022E-01	-3.2000E+00	0.	0.	1.0810E-02
3.0000E-01	5.5230E-01	2.7994E-01	1.5590E-01	8.3660E-01	5.9658E-01	-4.0110E+00	0.	0.	1.0227E-02
4.0000E-01	6.6420E-01	3.1163E-01	1.2800E-01	6.8796E-01	5.7789E-01	0.	-1.0783E-01	0.	9.5484E-03
5.0000E-01	7.5080E-01	3.3137E-01	1.0190E-01	5.8514E-01	4.9642E-01	1.0313E+01	-1.0044E-01	0.	9.1268E-03
6.0000E-01	7.9000E-01	3.3843E-01	7.9600E-02	5.0019E-01	4.7551E-01	2.1659E+01	-5.7609E-01	0.	8.8361E-03
7.0000E-01	8.1420E-01	3.3031E-01	6.0900E-02	4.3525E-01	3.7678E-01	3.2716E+01	-8.4609E-01	0.	8.6228E-03
8.0000E-01	8.3830E-01	3.0171E-01	4.6500E-02	3.8644E-01	3.3944E-01	4.4977E+01	-1.0500E+00	0.	8.4728E-03
9.0000E-01	8.5250E-01	2.3876E-01	3.9400E-02	3.4842E-01	3.1044E-01	5.4546E+01	-1.1522E+00	0.	8.3964E-03
9.5000E-01	8.7050E-01	1.7980E-01	4.3200E-02	3.3161E-01	2.9682E-01	5.7754E+01	-1.1400E+00	0.	8.4355E-03
1.0000E+00	8.7760E-01	0.	0.	3.1631E-01	2.9429E-01	6.0000E+01	-1.1217E+00	0.	8.0000E-03

^	TANBI	TAN B	G	UT/2V	UA/2V	DCTSI	DCPSI	VR(FT/SEC)	CAVV
1.7600E-01	1.3629E+00	7.9753E-01	0.	1.7344E-01	7.2549E-02	0.	0.	2.5924E+01	4.1774E+00
2.5000E-01	1.0216E+00	6.3657E-01	1.2573E-02	1.7119E-01	1.2393E-01	1.8257E-01	1.4477E-01	3.5561E+01	2.3276E+00
3.0000E-01	9.0325E-01	5.9317E-01	1.5332E-02	1.6023E-01	1.4179E-01	2.7822E-01	2.3330E-01	4.2665E+01	1.6379E+00
4.0000E-01	7.4031E-01	5.3482E-01	1.7126E-02	1.3240E-01	1.5719E-01	4.5603E-01	4.1927E-01	5.6750E+01	9.2882E-01
5.0000E-01	6.2967E-01	4.8364E-01	1.7743E-02	1.0747E-01	1.5902E-01	6.1528E-01	6.0143E-01	7.0204E+01	5.9911E-01
6.0000E-01	5.3325E-01	4.2408E-01	1.7997E-02	9.1931E-02	1.6322E-01	7.6495E-01	7.6700E-01	8.2691E+01	4.2267E-01
7.0000E-01	4.6837E-01	3.7463E-01	1.7790E-02	8.0229E-02	1.6515E-01	8.9365E-01	9.0957E-01	9.5031E+01	3.1239E-01
8.0000E-01	4.1585E-01	3.3751E-01	1.6630E-02	7.0068E-02	1.6545E-01	9.6335E-01	9.9504E-01	1.0748E+02	2.3805E-01
9.0000E-01	3.7494E-01	3.0567E-01	1.3498E-02	6.1269E-02	1.6277E-01	8.8535E-01	9.2757E-01	1.2001E+02	1.8593E-01
9.5000E-01	3.5685E-01	2.9513E-01	1.0250E-02	5.7852E-02	1.6139E-01	7.1132E-01	7.4869E-01	1.2624E+02	1.6574E-01
1.0000E+00	3.4039E-01	2.8266E-01	0.	5.4793E-02	1.6957E-01	0.	0.	1.3247E+02	1.4842E-01

CPTI=4.0193E-01	CPSI=5.1059E-01	ETAI=7.8718E-01	CTSI=5.1147E-01	CTSI/CPSI=1.0017E+00
CPT=3.9089E-01	CPS=5.7394E-01	ETA=6.8107E-01	CTS=4.9737E-01	CTS/CPS=8.6660E-01

X	CL	ALI(DEG)	FM/C	CD/CL	F(X)	LI(LBF/FT)	TETS(DEG)	(C/RD)LE	(C/RD)TE	T/RD
1.760E-01	0.	0.	0.	0.	0.	0.	0.	-2.248E-01	2.249E-01	9.709E-02
2.500E-01	3.535E-01	5.443E-01	2.400E-02	3.058E-02	1.943E-01	2.544E+03	-3.200E+00	-2.784E-01	2.384E-01	9.241E-02
3.000E-01	3.251E-01	5.007E-01	2.298E-02	3.145E-02	2.054E-01	3.793E+03	-4.011E+00	-3.082E-01	2.517E-01	8.897E-02
4.000E-01	2.532E-01	3.852E-01	1.699E-02	3.817E-02	2.129E-01	5.749E+03	0.	-3.116E-01	3.115E-01	7.977E-02
5.000E-01	1.970E-01	3.034E-01	1.338E-02	4.632E-02	2.188E-01	7.356E+03	1.031E+01	-2.250E-01	4.377E-01	6.753E-02
6.000E-01	1.661E-01	2.559E-01	1.128E-02	5.319E-02	2.215E-01	8.321E+03	2.165E+01	-8.086E-02	5.963E-01	5.388E-02
7.000E-01	1.464E-01	2.255E-01	9.941E-03	5.893E-02	2.261E-01	9.397E+03	3.272E+01	1.111E-01	7.717E-01	4.023E-02
8.000E-01	1.325E-01	2.340E-01	3.995E-03	6.396E-02	2.348E-01	1.357E+04	4.498E+01	3.784E-01	9.815E-01	2.824E-02
9.000E-01	1.217E-01	1.874E-01	8.263E-03	6.900E-02	2.459E-01	9.579E+03	5.455E+01	6.703E-01	1.154E+00	1.881E-02
9.500E-01	1.167E-01	1.797E-01	7.921E-03	7.231E-02	2.495E-01	7.571E+03	5.775E+01	9.369E-01	1.197E+00	1.554E-02
1.000E+00	0.	0.	0.	0.	0.	0.	6.000E+01	1.106E+00	1.105E+00	0.

ETAD=7.2534E-01	PS(HP) =2.9992E+04	1-THO=8.3700E-01	1-WTT=7.8500E-01	V(KNOTS) =2.4360E+01	DESIGN TH(LBF)=3.4767E+05
Z= 6	N(REV/MIN)=1.0600E+02		INPUT AE/AO=9.0000E-01	V(FT/SEC) =4.1115E+01	CALCULATED TH(LBF)=3.4767E+05

X	AREA (IN2)	XBAR (IN)	YBAR (IN)	IXO (IN4)	IYO (IN4)	MXO (IN-LBF)	MYO (IN-LBF)	MTB (IN-LBF)	MCB (IN-LBF)	MAXSTRESS (LBF/IN2)
1.760E-01	5.993E+02	2.934E+01	0.	6.374E+03	1.305E+05	-1.457E+05	9.869E+05	3.957E+06	2.135E+06	2.931E+03
3.000E-01	5.939E+02	3.654E+01	1.217E-01	6.060E+03	2.311E+05	-2.743E+06	9.165E+06	7.077E+06	1.556E+06	2.657E+03
4.000E-01	6.826E+02	4.068E+01	8.791E-02	4.862E+03	2.957E+05	-2.399E+07	-4.966E+06	7.233E+06	1.134E+06	4.179E+03
5.000E-01	6.145E+02	4.326E+01	6.242E-02	3.137E+03	2.909E+05	-1.351E+07	-2.931E+06	1.[illegible]E+06	7.609E+05	2.217E+04
6.000E-01	5.337E+02	4.419E+01	3.276E-02	1.627E+03	2.472E+05	-1.791E+07	-1.586E+06	9.846E+05	4.708E+05	2.656E+04
7.000E-01	3.649E+02	4.312E+01	0.	6.612E+02	1.715E+05	-6.129E+06	9.944E+05	5.754E+05	2.441E+05	3.149E+03
8.000E-01	2.340E+02	3.938E+01	0.	2.089E+02	9.193E+04	-1.693E+06	4.085E+05	2.129E+05	9.591E+04	1.270E+04

X	RAKG/D	PI XTANPI	PI XTANP
1.760E-01	0.	7.536E-01	4.410E-01
2.500E-01	0.	8.074E-01	5.000E-01
3.000E-01	0.	8.485E-01	5.591E-01
4.000E-01	-1.078E-01	9.303E-01	6.721E-01
5.000E-01	-1.034E-01	9.891E-01	7.597E-01
6.000E-01	-5.761E-01	1.015E+00	7.994E-01
7.000E-01	-8.461E-01	1.030E+00	8.239E-01
8.000E-01	-1.059E+00	1.045E+00	8.487E-01
9.000E-01	-1.157E+00	1.060E+00	9.727E-01
9.500E-01	-1.140E+00	1.065E+00	8.909E-01
1.000E+00	-1.122E+00	1.069E+00	8.893E-01

WEIGHT OF BLADES(LBF)= 85218.4643

WEIGHT OF PROP (BLADES + CYLINDRICAL HUB)(LBF)= 112424.9998

CENTER OF GRAVITY OF PROP REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= -.225937

CENTER OF GRAVITY OF BLADES REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= -.292766

HUB DIMENSIONS/D
HUB DIAM = .1757
HUB LENGTH = .1768
MIDCHORD OF ROOT SECTION TO AFT END OF HUB = .0888

KELLERS MINIMUM EAR= .7666E+00

SPEED COEFF V/(ND) JS= .1012E+01

ADVANCE COEFF V(1-WTT)/(ND) JA= .7943E+00

DESIGN THRUST COEFF KT= .2000E+00

TORQUE COEFF KQ= .3716E-01

PROPULSIVE EFFICIENCY ETAD= .7253E+00

BURRILL THRUST COEFF TC= .1234E+00

BURRILL CAVITATION COEFF SIGMA(0.7)= .3678E+00

CLEARANCE AT HUB BETWEEN BLADES/D= 3.1940E-02

CLEARANCE AT HUB BETWEEN FILLETS/D= -2.2251E-02

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MASS POLAR MOMENT OF INERTIA OF BLADES (LBM-IN2)=  .365230E+09

TOTAL MASS POLAR MOMENT OF INERTIA (LBM-IN2)=  .355230E+09

RADIUS OF GYRATION OF BLADE/D=    .2372

RADIUS OF GYRATION OF HUB/D=   0.0000

TOTAL RADIUS OF GYRATION/D=    .2084


          ABS COEFFICIENTS (CALCULATED AT THE .25 RADIUS)

ABS MINIMUM THICKNESS IN INCHES (USING P/D=PIXTAN9I)-
                   USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.2184E-01
                   USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.2184E-01

VALUES USED IN DETERMINING THICKNESS-      A=  .102755E+02
                                           B=  .297597E+03
                                           C=  .127529E+05

SECTION AREA COEFFICIENT     CS=  .6942E+00

SECTION MODULUS COEFFICIENT     CN=  .8558E-01

AREA OF EXPANDED CYLINDRICAL SECTION IN SQ.INCHES     AS= .6313E+03


FOR CN=.1
ABS MINIMUM THICKNESS IN INCHES (USING P/D=PIXTAN9I)-
                   USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.1651E-01
                   USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.1651E-01
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RADIAL PROPELLER DATA FOR INPUT INTO DESIGN PROGRAMS(8 RADIAL STRIPS ASSUMED)

XR	TAN BETA I	G	XSL(INCHES)	XST(INCHES)	1-WX	UA/2VS	THICKNESS(INCHES)
.22750	1.09957	.1031E-01	-36.13313	32.32775	.47103	.1122E+00	12.94715
.27938	.94487	.1473E-01	-41.32421	33.94115	.52733	.1355E+00	12.49636
.38200	.76381	.1692E-01	-43.83671	43.95175	.64531	.1559E+00	11.27012
.48500	.64469	.1769E-01	-33.47456	57.47793	.74091	.1598E+00	9.59063
.58833	.54907	.1799E-01	-13.87741	79.59219	.79656	.1627E+00	7.65533
.69133	.47388	.1784E-01	12.50244	104.35197	.91214	.1656E+00	5.71473
.79430	.41861	.1673E-01	49.86253	133.78914	.83678	.1696E+00	3.98818
.89730	.37607	.1359E-01	92.17359	159.59970	.86194	.1673E+00	2.60942
.94850	.35737	.1042E-01	114.69215	165.13721	.87029	.1514E+00	2.17175
1.00000			152.65573	152.65573			

DOC.   TION CASE A

PS(HP)= 3.0000E+04, DENSITY OF PROP(LBM/FT3)= 483.8400

V(KNOTS)	2.3500E+01	2.4000E+01	2.4500E+01	2.4700E+01	2.5000E+01
PE(HP)	1.9329E+04	2.0755E+04	2.2246E+04	2.3052E+04	2.4277E+04

D(FT)= 23.0000 ,1-WTT=.7450 ,1-THD=.8370 ,H(FT)= 52.0000 ,RHO(SLUG/FT3)= 1.9905

Z	6	5	
AE/AO	7.6483E-01	7.6800E-01	9.0000E-01
N(REV/MIN)	1.3600E+02	1.2000E+02	

X INPUT	1-WX INPUT	C/D ADJUSTED	T/C INPUT	TANBI LERBS	TANB CALCULATED	TETS(DEG) NONLINEAR	RAKG/D NONLINEAR	P/D PIXTANBI	CD CALCULATED
1.7600E-01	4.3580E-01	2.2476E-01	2.1600E-01	1.1187E+00	7.0952E-01	0.	0.	0.	1.2337E-02
2.5000E-01	4.9410E-01	2.5841E-01	1.7860E-01	8.3862E-01	5.6553E-01	-3.2003E+00	0.	0.	1.0818E-02
3.0000E-01	5.5250E-01	2.7994E-01	1.5890E-01	7.3999E-01	5.2599E-01	-4.0110E+00	0.	0.	1.0227E-02
4.0000E-01	6.6420E-01	3.1160E-01	1.2800E-01	6.0769E-01	4.7514E-01	0.	-1.0753E-01	0.	9.5484E-03
5.0000E-01	7.5040E-01	3.3137E-01	1.0190E-01	5.1699E-01	4.2957E-01	1.0313E+01	-1.0044E-01	0.	9.1263E-03
6.0000E-01	7.9003E-01	3.3843E-01	7.9500E-02	4.4183E-01	3.7575E-01	2.1659E+01	-5.7609E-01	0.	8.8361E-03
7.0000E-01	8.1420E-01	3.3231E-01	6.0900E-02	3.8447E-01	3.3292E-01	3.2716E+01	-8.4679E-01	0.	8.6228E-03
8.0000E-01	8.3830E-01	3.3171E-01	4.6800E-02	3.4135E-01	2.3984E-01	4.4977E+01	-1.0530E+00	0.	8.4728E-03
9.0000E-01	8.6250E-01	2.3976E-01	3.9400E-02	3.0777E-01	2.7422E-01	5.4545E+01	-1.1522E+00	0.	8.3964E-03
9.5000E-01	8.7050E-01	1.7950E-01	4.3200E-02	2.9237E-01	2.6220E-01	5.7754E+01	-1.1430E+00	0.	8.4359E-03
1.0000E+00	8.7760E-01	0.	0.	2.7941E-01	2.5112E-01	6.0000E+01	-1.1217E+00	0.	8.0000E-03

X	TANBI	TAN B	G	UT/2V	UA/2V	DCTSI	DCPSI	VP(FT/SEC)	CAVV
1.7600E-01	1.1588E+00	6.9549E-01	0.	1.7539E-01	9.1581E-02	0.	0.	2.8173E+01	3.5767E+00
2.5000E-01	8.7615E-01	5.5513E-01	1.2117E-02	1.6447E-01	1.4153E-01	2.1100E-01	1.6455E-01	3.9158E+01	1.9365E+00
3.0000E-01	7.7207E-01	5.1729E-01	1.4121E-02	1.5001E-01	1.5531E-01	3.1114E-01	2.5657E-01	4.7079E+01	1.3539E+00
4.0000E-01	6.3489E-01	4.6640E-01	1.5404E-02	1.1864E-01	1.6463E-01	4.9763E-01	4.3637E-01	6.2767E+01	7.6194E-01
5.0000E-01	5.4301E-01	4.2177E-01	1.5425E-02	9.2989E-02	1.6933E-01	6.2434E-01	6.0046E-01	7.7834E+01	4.9814E-01
6.0000E-01	4.6161E-01	3.6982E-01	1.5314E-02	7.7434E-02	1.6932E-01	7.5664E-01	7.4610E-01	9.2038E+01	3.4145E-01
7.0000E-01	4.0168E-01	3.2670E-01	1.4976E-02	6.6367E-02	1.6929E-01	8.7197E-01	8.7290E-01	1.0611E+02	2.5066E-01
8.0000E-01	3.5653E-01	2.9433E-01	1.3981E-02	5.7073E-02	1.5711E-01	9.3658E-01	9.5134E-01	1.2028E+02	1.9012E-01
9.0000E-01	3.2155E-01	2.6918E-01	1.1444E-02	4.9224E-02	1.5193E-01	9.6555E-01	9.9294E-01	1.3457E+02	1.4779E-01
9.5000E-01	3.2604E-01	2.5737E-01	8.7548E-03	4.6236E-02	1.5944E-01	7.0095E-01	7.2554E-01	1.4161E+02	1.3171E-01
1.0000E+00	2.9192E-01	2.4650E-01	0.	4.3594E-02	1.4999E-01	0.	0.	1.4870E+02	1.1778E-01

CPTI=4.0030E-01 CPSI=5.0118E-01 ETAI=7.9871E-01 CTSI=5.1179E-01 CTSI/CPSI=1.0211E+00
CPT=3.8788E-01 CPS=5.9644E-01 ETA=6.5032E-01 CTS=4.9591E-01 CTS/CPS=8.3143E-01

X	CL	ALI(DEG)	FM/C	CD/CL	F(X)	LI(LBF/FT)	TETS(DEG)	(C/R)OILE	(C/R)OITE	T/RO
1.760E-01	0.	0.	0.	0.	0.	0.	0.	-2.248E-01	2.249E-01	9.709E-02
2.500E-01	3.054E-01	4.703E-01	2.074E-02	3.540E-02	1.837E-01	2.779E+03	-3.200E+00	-2.770E-01	2.359E-01	9.241E-02
3.000E-01	2.733E-01	4.208E-01	1.855E-02	3.742E-02	1.923E-01	3.981E+03	-4.011E+00	-3.065E-01	2.534E-01	8.897E-02
4.000E-01	2.009E-01	3.093E-01	1.364E-02	4.753E-02	1.974E-01	5.545E+03	0.	-3.116E-01	3.116E-01	7.977E-02
5.000E-01	1.525E-01	2.349E-01	1.036E-02	5.983E-02	2.013E-01	7.099E+03	1.031E+01	-2.291E-01	4.336E-01	6.753E-02
6.000E-01	1.254E-01	1.931E-01	9.514E-03	7.047E-02	2.029E-01	9.279E+03	2.166E+01	-8.863E-02	5.887E-01	5.358E-02
7.000E-01	1.090E-01	1.678E-01	7.399E-03	7.913E-02	2.074E-01	9.577E+03	3.272E+01	1.074E-01	7.610E-01	4.023E-02
8.000E-01	9.826E-02	1.513E-01	6.672E-03	8.623E-02	2.171E-01	9.919E+03	4.499E+01	3.690E-01	9.693E-01	2.824E-02
9.000E-01	9.085E-02	1.399E-01	6.173E-03	9.239E-02	2.304E-01	8.914E+03	5.455E+01	6.617E-01	1.137E+00	1.881E-02
9.500E-01	8.769E-02	1.350E-01	5.954E-03	9.616E-02	2.363E-01	7.239E+03	5.775E+01	9.216E-01	1.181E+00	1.554E-02
1.000E+00	0.	0.	0.	0.	0.	0.	6.000E+01	1.091E+00	1.091E+00	0.

ETAD=6.9591E-01 PS(HP) =2.9993E+04 1-THD=8.3700E-01 1-WTT=7.4570E-01 V(KNOTS) =2.4649E+01 DESIGN TH(LBF)=3.3785E+05
Z= 6 N(REV/MIN)=1.2000E+02 INPUT AE/AO=9.0000E-01 V(FT/SEC) =4.1601E+01 CALCULATED TH(LBF)=3.3785E+05

X	AREA (IN2)	XBAR (IN)	YBAR (IN)	IXO (IN4)	IYO (IN4)	MXO (IN-LBF)	MYO (IN-LBF)	MTO (IN-LBF)	MOB (IN-LBF)	MAXSTRESS (LBF/IN2)
1.760E-01	5.993E+02	2.934E+01	0.	6.324E+03	1.335E+05	-2.979E+06	2.484E+05	3.792E+06	1.882E+06	4.243E+03
3.000E-01	6.839E+02	3.554E+01	9.775E-02	6.063E+03	2.311E+05	-4.419E+06	9.595E+06	2.941E+06	1.360E+06	3.844E+03
4.000E-01	6.826E+02	4.068E+01	6.527E-02	4.864E+03	2.857E+05	-3.379E+07	-4.970E+05	2.125E+06	9.969E+05	5.562E+03
5.000E-01	6.145E+02	4.376E+01	4.510E-02	3.137E+03	2.920E+05	-2.794E+07	-2.653E+06	1.482E+06	5.766E+05	3.008E+04
6.000E-01	5.007E+02	4.418E+01	2.462E-02	1.527E+03	2.472E+05	-2.411E+07	-3.386E+06	9.343E+05	4.156E+05	3.540E+04
7.000E-01	3.645E+02	4.312E+01	0.	6.612E+02	1.716E+05	-9.756E+06	1.380E+06	4.991E+05	2.165E+05	2.972E+03
8.000E-01	2.343E+02	3.938E+01	0.	2.049E+02	9.193E+04	-2.795E+06	6.144E+05	2.028E+05	9.564E+04	1.664E+04

X	RAKG/D	PI XTANPI	PI XTANP
1.760E-01	0.	6.463E-01	3.946E-01
2.500E-01	0.	6.881E-01	4.350E-01
3.000E-01	0.	7.277E-01	4.875E-01
4.000E-01	-1.978E-01	7.979E-01	5.861E-01
5.000E-01	-1.304E-01	8.493E-01	6.625E-01
6.000E-01	-5.761E-01	8.701E-01	6.971E-01
7.000E-01	-9.461E-01	8.832E-01	7.185E-01
8.000E-01	-1.059E+00	8.953E-01	7.397E-01
9.000E-01	-1.152E+00	9.092E-01	7.611E-01
9.500E-01	-1.143E+00	9.134E-01	7.681E-01
1.000E+00	-1.122E+00	9.171E-01	7.744E-01

WEIGHT OF BLADES(LBF)= 85218.4643

WEIGHT OF PROP (BLADES + CYLINDRICAL HUB)(LBF)= 118424.9998

CENTER OF GRAVITY OF PROP REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= -.229843

CENTER OF GRAVITY OF BLADES REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= -.298791

HUB DIMENSIONS/D
HUB DIAM = .1769
HUB LENGTH = .1769
MIDCHORD OF ROOT SECTION TO AFT END OF HUB = .0898

KELLERS MINIMUM EAR= .7481E+00

SPEED COEFF V/(ND) JS= .8824E+00

ADVANCE COEFF V(1-WTT)/(ND) JA= .5927E+00

DESIGN THRUST COEFF KT= .1516E+00

TORQUE COEFF KQ= .2561E-01

PROPULSIVE EFFICIENCY ETAD= .6959E+00

BURRILL THRUST COEFF TC= .9277E-01

BURRILL CAVITATION COEFF SIGMA(0.7)= .2957E+00

CLEARANCE AT HUB BETWEEN BLADES/D= 2.8263E-02

CLEARANCE AT HUB BETWEEN FILLETS/D= -2.9239E-02

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MASS POLAR MOMENT OF INERTIA OF BLADES (LBM-IN2)=  .365236E+09

TOTAL MASS POLAR MOMENT OF INERTIA (LBM-IN2)=  .365236E+09

RADIUS OF GYRATION OF BLADE/D=    .2372

RADIUS OF GYRATION OF HUB/D=   0.0000

TOTAL RADIUS OF GYRATION/D=    .2384


         ABS COEFFICIENTS (CALCULATED AT THE .25 RADIUS)

ABS MINIMUM THICKNESS IN INCHES (USING P/D=PITTANB(I)-
                     USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.4343E-01
                     USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.4343E-01

VALUES USED IN DETERMINING THICKNESS-     A=  .127514E+02
                                          B=  .781199E+03
                                          C=  .115447E+05

SECTION AREA COEFFICIENT     CS=  .6942E+00

SECTION MODULUS COEFFICIENT     CN=  .0558E-01

AREA OF EXPANDED CYLINDRICAL SECTION IN SQ.INCHES     AS= .6313E+03



FOR CN=.1
ABS MINIMUM THICKNESS IN INCHES (USING P/D=PITTAN(I)-
                     USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.3498E-01
                     USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.3498E-01
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RADIAL PROPELLER DATA FOR INPUT INTO DESIGN PROGRAMS(8 RADIAL STRIPS ASSUMED)

XR	TAN BETA I	G	XSL(INCHES)	XST(INCHES)	1-WX	UA/2VS	THICKNESS(INCHES)
.22750	.94214	.1004E-01	-35.98894	32.47734	.67103	.1308E+00	12.94715
.27900	.81033	.1358E-01	-40.79336	34.07720	.52733	.1514E+00	12.48638
.38200	.65505	.1533E-01	-43.76336	40.97450	.64531	.1646E+00	11.27312
.48500	.55289	.1544E-01	-33.89983	56.05192	.74991	.1609E+00	9.59043
.59800	.47003	.1533E-01	-14.89972	78.49798	.79656	.1633E+00	7.66533
.69100	.40540	.1502E-01	11.07372	102.61015	.81216	.1603E+00	5.71473
.79400	.35900	.1407E-01	48.03371	131.95932	.83678	.1574E+00	3.98818
.89700	.32252	.1152E-01	90.10197	155.51557	.96194	.1521E+00	2.60942
.94850	.30649	.9896E-02	112.58059	163.02545	.97029	.1535E+00	2.17175
1.00000			150.54482	150.54492			

DOCUMENTATION CASE A

PS(HP)= 3.0000E+04, DENSITY OF PROP(LBM/FT3)= 483.8430

V(KNOTS)	2.3500E+01	2.4000E+01	2.4500E+01	2.4700E+01	2.5000E+01
PE(HP)	1.9379E+04	2.0756E+04	2.2246E+04	2.3052E+04	2.4277E+04

D(FT)= 23.0000 ,1-WTT=.7850 ,1-THD=.8370 ,H(FT)= 52.0000 ,RHO(SLUG/FT3)= 1.9905

Z	6	5	
AE/AO	7.6483E-01	7.6800E-01	9.0000E-01
N(REV/MIN)	1.5600E+02	1.2000E+02	

X INPUT	1-WX INPUT	C/D ADJUSTED	T/C INPUT	TANBI LERPS	TANB CALCULATED	TETS(DEG) NONLINEAR	RAKG/D NONLINEAR	P/D PIXTANBI	CD CALCULATED
1.7600E-01	4.3590E-01	2.2920E-01	2.1600E-01	1.2655E+00	8.9210E-01	0.	0.	0.	1.2337E-02
2.5000E-01	4.9410E-01	2.6352E-01	1.7980E-01	9.4938E-01	6.4972E-01	-3.2000E+00	0.	0.	1.0810E-02
3.0000E-01	5.5250E-01	2.8548E-01	1.5990E-01	9.7650E-01	5.9659E-01	-4.0110E+00	0.	0.	1.0227E-02
4.0000E-01	6.6420E-01	3.1776E-01	1.2900E-01	6.8795E-01	5.3749E-01	0.	-1.0783E-01	0.	9.5484E-03
5.0000E-01	7.5090E-01	3.3792E-01	1.0190E-01	5.8514E-01	4.9642E-01	1.0311E+01	-1.0044E-01	0.	9.1268E-03
6.0000E-01	7.9000E-01	3.4512E-01	7.9600E-02	5.0019E-01	4.2651E-01	2.1659E+01	-9.7639E-01	0.	8.8361E-03
7.0000E-01	8.1420E-01	3.3694E-01	6.0900E-02	4.3525E-01	3.7579E-01	3.2715E+01	-9.4639E-01	0.	8.6228E-03
8.0000E-01	8.2830E-01	3.0769E-01	4.6900E-02	3.8644E-01	3.3944E-01	4.4977E+01	-1.0900E+00	0.	8.4728E-03
9.0000E-01	8.6250E-01	2.4348E-01	3.9400E-02	3.4842E-01	3.1344E-01	5.4546E+01	-1.1522E+00	0.	8.3964E-03
9.5000E-01	8.7050E-01	1.8336E-01	4.3200E-02	3.3161E-01	2.9692E-01	5.7754E+01	-1.1430E+00	0.	8.4355E-03
1.0000E+00	8.7760E-01	0.	0.	3.1631E-01	2.9420E-01	6.0000E+01	-1.1217E+00	0.	8.0380E-03

X	TANBI	TAN B	G	UT/2V	UA/2V	DCTSI	DCPSI	VR(FT/SEC)	CAVV
1.7600E-01	1.3798E+00	8.0058E-01	0.	1.7519E-01	7.3519E-02	0.	0.	2.4965E+01	4.1742E+00
2.5000E-01	1.0343E+00	6.3900E-01	1.4785E-02	1.7395E-01	1.2575E-01	1.7721E-01	1.4173E-01	3.1584E+01	2.3274E+00
3.0000E-01	9.1147E-01	5.9544E-01	1.7935E-02	1.6355E-01	1.4417E-01	2.7416E-01	2.3197E-01	4.2643E+01	1.6376E+00
4.0000E-01	7.4953E-01	5.3687E-01	2.0941E-02	1.3650E-01	1.6279E-01	4.5879E-01	4.2543E-01	5.6772E+01	9.2844E-01
5.0000E-01	6.3751E-01	4.9549E-01	2.1819E-02	1.1190E-01	1.6747E-01	6.2696E-01	6.1721E-01	7.0222E+01	5.9801E-01
6.0000E-01	5.4495E-01	4.2570E-01	2.2134E-02	9.6134E-02	1.6997E-01	7.7494E-01	7.8775E-01	8.2768E+01	4.2248E-01
7.0000E-01	4.7420E-01	3.7606E-01	2.1752E-02	8.4263E-02	1.7252E-01	9.0115E-01	9.2725E-01	9.5046E+01	3.1227E-01
8.0000E-01	4.2102E-01	3.3880E-01	1.9983E-02	7.3896E-02	1.7235E-01	9.5936E-01	9.9943E-01	1.0750E+02	2.3797E-01
9.0000E-01	3.7961E-01	3.0984E-01	1.5870E-02	6.4873E-02	1.6957E-01	9.6291E-01	9.1194E-01	1.2002E+02	1.8587E-01
9.5000E-01	3.6129E-01	2.9626E-01	1.1898E-02	6.1335E-02	1.6997E-01	5.9463E-01	7.2679E-01	1.2625E+02	1.6569E-01
1.0000E+00	3.4462E-01	2.8374E-01	0.	5.9167E-02	1.6925E-01	0.	0.	1.3240E+02	1.4038E-01

CPTI=4.0141E-01	CPSI=5.1442E-01	ETAI=7.8032E-01	CTSI=5.1098E-01	CTSI/CPSI=9.9333E-01
CPT=3.9201E-01	CPS=5.6754E-01	ETA=6.9072E-01	CTS=4.9897E-01	CTS/CPS=8.7919E-01

X	CL	ALI(DEG)	FW/C	CD/CL	F(X)	LI(LBF/FT)	TETS(DEG)	(C/RO)LE	(C/RO)TE	T/RO
1.760E-01	0.	0.	0.	0.	0.	0.	0.	-2.292E-01	2.292E-01	9.931E-02
2.500E-01	4.099E-01	5.297E-01	2.776E-02	2.644E-02	2.147E-01	3.123E+03	-3.200E+00	-2.836E-01	2.434E-01	9.423E-02
3.000E-01	3.817E-01	5.878E-01	2.592E-02	2.679E-02	2.297E-01	4.546E+03	-4.011E+00	-3.139E-01	2.571E-01	9.073E-02
4.000E-01	2.996E-01	4.614E-01	2.034E-02	3.187E-02	2.392E-01	7.323E+03	0.	-3.178E-01	3.178E-01	8.135E-02
5.000E-01	2.394E-01	3.672E-01	1.613E-02	3.828E-02	2.464E-01	9.395E+03	1.031E+01	-2.312E-01	4.447E-01	6.887E-02
6.000E-01	2.011E-01	3.097E-01	1.367E-02	4.394E-02	2.495E-01	1.397E+04	2.166E+01	-8.693E-02	6.034E-01	5.494E-02
7.000E-01	1.758E-01	2.707E-01	1.194E-02	4.905E-02	2.514E-01	1.224E+04	3.272E+01	1.055E-01	7.792E-01	4.103E-02
8.000E-01	1.567E-01	2.413E-01	1.064E-02	5.408E-02	2.573E-01	1.275E+04	4.499E+01	3.737E-01	9.891E-01	2.838E-02
9.000E-01	1.408E-01	2.169E-01	9.542E-03	5.962E-02	2.647E-01	1.131E+04	5.455E+01	6.710E-01	1.163E+00	1.919E-02
9.500E-01	1.333E-01	2.053E-01	9.050E-03	6.329E-02	2.653E-01	9.917E+03	5.775E+01	8.349E-01	1.207E+00	1.584E-02
1.000E+00	0.	0.	0.	0.	0.	0.	6.000E+01	1.128E+00	1.139E+00	0.

ETAD=7.3598E-01	PS(HP) =2.9999E+04	1-THD=8.3700E-01	1-WTT=7.8500E-01	V(KNOTS) =2.4483E+01	DESIGN TH(LBF)=3.5146E+05
Z= 5	N(REV/MIN)=1.0600E+02		AE/AO=7.6483E-01	V(FT/SEC) =4.1277E+01	CALCULATED TH(LBF)=3.5146E+05

X	AREA (IN2)	XBAR (IN)	YBAR (IN)	IXO (IN4)	IYO (IN4)	MXO (IN-LBF)	MYO (IN-LBF)	MTB (IN-LBF)	M2B (IN-LBF)	MAXSTRESS (LBF/IN2)
1.760E-01	6.232E+02	2.997E+01	0.	6.839E+03	1.411E+05	-8.169E+05	1.414E+06	4.792E+06	1.559E+06	2.718E+03
3.000E-01	7.113E+02	3.727E+01	1.487E-01	6.591E+03	2.690E+05	-1.774E+06	8.721E+06	3.991E+06	1.461E+06	2.919E+03
4.000E-01	7.092E+02	4.149E+01	1.384E-01	5.259E+03	1.693E+05	-2.641E+07	-9.159E+06	2.694E+06	1.353E+06	4.125E+03
5.000E-01	6.391E+02	4.411E+01	7.529E-02	3.391E+03	3.146E+05	-1.494E+07	-3.263E+06	1.073E+06	9.127E+05	2.139E+03
6.000E-01	5.207E+02	4.535E+01	3.917E-02	1.763E+03	2.676E+05	-1.963E+07	-3.797E+06	1.177E+06	5.559E+05	2.399E+03
7.000E-01	3.795E+02	4.307E+01	0.	7.181E+02	1.896E+05	-4.771E+06	5.197E+05	[illegible]	2.806E+05	3.983E+03
8.000E-01	2.433E+02	4.016E+01	0.	2.259E+02	9.911E+04	-1.715E+05	4.196E+05	[illegible]	1.114E+05	1.249E+03

X	PAKG/D	PI XTANPI	PI XTANP
1.760E-01	0.	7.629E-01	6.427E-01
2.500E-01	0.	9.124E-01	5.019E-01
3.000E-01	0.	8.590E-01	5.612E-01
4.000E-01	-1.079E-01	9.619E-01	6.746E-01
5.000E-01	-1.034E-01	1.001E+00	7.626E-01
6.000E-01	-5.761E-01	1.027E+00	9.024E-01
7.000E-01	-9.461E-01	1.049E+00	9.270E-01
8.000E-01	-1.053E+00	1.058E+00	9.515E-01
9.000E-01	-1.152E+00	1.073E+00	9.761E-01
9.500E-01	-1.140E+00	1.078E+00	9.942E-01
1.000E+00	-1.122E+00	1.043E+00	9.914E-01

WEIGHT OF BLADES(LBF)= 73852.0224

WEIGHT OF PROP (BLADES + CYLINDRICAL HUB)(LBF)= 99854.5596

CENTER OF GRAVITY OF PROP REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= -.218482

CENTER OF GRAVITY OF BLADES REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= -.293857

HUB DIMENSIONS/D
HUB DIAM = .1760
HUB LENGTH = .1743
MIDCHORD OF ROOT SECTION TO AFT END OF HUB = .0888

KELLERS MINIMUM EAR= .7131E+00

SPEED COEFF V/(ND) JS= .1016E+01

ADVANCE COEFF V(1-WTT)/(ND) JA= .7973E+00

DESIGN THRUST COEFF KT= .2322E+00

TORQUE COEFF KQ= .3717E-01

PROPULSIVE EFFICIENCY ETAO= .7359E+00

BURRILL THRUST COEFF TC= .1472E+00

BURRILL CAVITATION COEFF SIGMA(0.7)= .3574E+00

CLEARANCE AT HUB BETWEEN BLADES/D= 4.9663E-02

CLEARANCE AT HUB BETWEEN FILLETS/D= -5.9945E-03

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MASS POLAR MOMENT OF INERTIA OF BLADES (LBM-IN2)=  .315516E+09

TOTAL MASS POLAR MOMENT OF INERTIA (LBM-IN2)=  .315516E+09

RADIUS OF GYRATION OF BLADE/D=    .2372

RADIUS OF GYRATION OF HUB/D=   0.0000

TOTAL RADIUS OF GYRATION/D=    .2049


        ABS COEFFICIENTS (CALCULATED AT THE .25 RADIUS)

ABS MINIMUM THICKNESS IN INCHES (USING P/D=PIXTAN9T)-
                 USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.1897E-01
                 USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.1897E-01

VALUES USED IN DETERMINING THICKNESS-      A=  .102469E+02
                                           B=  .707443E+03
                                           C=  .133422E+05

SECTION AREA COEFFICIENT     CS=  .6942E+00

SECTION MODULUS COEFFICIENT     CN=  .8558E-01

AREA OF EXPANDED CYLINDRICAL SECTION IN SQ.INCHES     AS= .6565E+03



FOR CN=.1
ABS MINIMUM THICKNESS IN INCHES (USING P/D=PIXTAN9T)-
                 USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.1389E-01
                 USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.1389E-01
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RADIAL PROPELLER DATA FOR INPUT INTO DESIGN PROGRAMS(8 RADIAL STRIPS ASSUMED)

XP	TAN BETA I	G	XSL(INCHES)	YST(INCHES)	1-WX	UA/2VS	THICKNESS(INCHES)
.22750	1.11224	.1205E-01	-36.82320	32.99150	.47183	.1137E+00	13.28320
.27930	.95564	.1695E-01	-41.78567	34.58931	.52733	.1376E+00	12.73330
.38230	.77332	.2053E-01	-44.58358	41.68190	.64531	.1593E+00	11.49301
.49500	.65270	.2173E-01	-34.27998	58.35844	.74091	.1534E+00	9.78089
.58830	.55499	.2213E-01	-14.70096	80.51921	.78656	.1693E+00	7.81693
.69133	.47979	.2179E-01	11.73098	105.19133	.81714	.1723E+00	5.92775
.79400	.42382	.2013E-01	49.20401	134.79936	.83478	.1725E+00	4.05706
.89730	.39075	.1633E-01	91.71134	159.43959	.85194	.1696E+00	2.66102
.94950	.36182	.1210E-01	114.39172	165.83418	.87029	.1699E+00	2.21470
1.00000			152.85417	152.85417			

DOCUMENTATION CASE A

PS(HP)= 3.0000E+04, DENSITY OF PROP(LBM/FT3)= 483.4400

V(KNOTS)	2.3500E+01	2.4000E+01	2.4500E+01	2.4700E+01	2.5000E+01
PE(HP)	1.9129E+04	2.0796E+04	2.2246E+04	2.3957E+04	2.4777E+04

D(FT)= 23.0000 ,1-WT= .7452 ,1-THO= .8370 ,H(FT)= 22.0000 ,RHO(SLUG/FT3)= 1.9935

Z	6	5	
AE/AO	7.6683E-01	7.6500E-01	9.0000E-01
N(REV/MIN)	1.0680E+02	1.2000E+02	

X INPUT	1-WX INPUT	C/D ADJUSTED	T/C INPUT	TANBI LESS	TANB CALCULATED	TETS(DEG) NONLINEAR	RAKG/D NONLINEAR	P/D PIXTANBI	CD CALCULATED
1.7600E-01	4.3550E-01	2.2920E-01	2.1600E-01	1.1197E+00	7.3952E-01	0.	0.	0.	1.2337E-02
2.5000E-01	4.9410E-01	2.6357E-01	1.7800E-01	9.3867E-01	5.6553E-01	-3.2003E+00	0.	0.	1.3018E-02
3.0000E-01	5.7250E-01	2.8564E-01	1.5890E-01	7.3909E-01	5.7599E-01	-4.0110E+00	0.	0.	1.0227E-02
4.0000E-01	6.6425E-01	3.1776E-01	1.2900E-01	6.0769E-01	4.7514E-01	0.	-1.0783E-01	0.	9.5696E-03
5.0000E-01	7.5840E-01	3.3792E-01	1.0140E-01	5.1699E-01	4.2967E-01	1.0313E+01	-1.8044E-01	0.	9.1208E-03
6.0000E-01	7.9000E-01	3.4712E-01	7.9600E-02	4.6193E-01	3.7675E-01	2.1659E+01	-5.7409E-01	0.	8.8361E-03
7.0000E-01	9.1420E-01	3.3496E-01	6.0900E-02	3.8447E-01	3.1792E-01	3.2715E+01	-9.4609E-01	0.	8.6228E-03
8.0000E-01	9.7470E-01	3.2749E-01	4.6900E-02	3.4135E-01	2.9964E-01	4.4977E+01	-1.0537E+00	0.	8.4770E-03
9.0000E-01	8.6759E-01	2.6149E-01	3.9450E-02	3.0777E-01	2.7672E-01	5.6556E+01	-1.1527E+00	0.	8.3966E-03
9.5000E-01	8.7059E-01	1.9336E-01	4.3200E-02	2.9292E-01	2.6723E-01	5.7756E+01	-1.1460E+00	0.	8.4155E-03
1.0000E+00	9.7760E-01	0.	0.	2.7941E-01	2.7112E-01	6.0300E+01	-1.1217E+00	0.	8.8000E-03

X	TANBI	TAN B	G	UT/2V	UA/2V	DCTSI	DCPSI	VP(FT/SEC)	CAVV
1.7600E-01	1.1965E+00	7.0151E-01	0.	1.7641E-01	9.1903E-02	0.	0.	2.8259E+01	3.5629E+00
2.5000E-01	8.4963E-01	5.5903E-01	1.6157E-02	1.6661E-01	1.6795E-01	2.3767E-01	1.5937E-01	3.9221E+01	1.9318E+00
3.0000E-01	7.2377E-01	5.2176E-01	1.6779E-02	1.5269E-01	1.6777E-01	3.0611E-01	2.5540E-01	4.1161E+01	1.3509E+00
4.0000E-01	6.4651E-01	4.7263E-01	1.9718E-02	1.2103E-01	1.6723E-01	4.9702E-01	4.3143E-01	5.2832E+01	7.6029E-01
5.0000E-01	5.4919E-01	4.2642E-01	1.9978E-02	9.4215E-02	1.6397E-01	6.3335E-01	6.1776E-01	7.7908E+01	4.9717E-01
6.0000E-01	4.6960E-01	3.7332E-01	1.8472E-02	8.2619E-02	1.6464E-01	7.6493E-01	7.6310E-01	9.2111E+01	3.4090E-01
7.0000E-01	4.0777E-01	3.2903E-01	1.8329E-02	6.7347E-02	1.6597E-01	8.9074E-01	8.8695E-01	1.0618E+02	2.5033E-01
8.0000E-01	3.6704E-01	2.9627E-01	1.6866E-02	5.9559E-02	1.5716E-01	9.1179E-01	9.5258E-01	1.2035E+02	1.8991E-01
9.0000E-01	3.2642E-01	2.7150E-01	1.3464E-02	5.1917E-02	1.5755E-01	9.4149E-01	9.7259E-01	1.3458E+02	1.4785E-01
9.5000E-01	3.1067E-01	2.5903E-01	1.0147E-02	4.4731E-02	1.5517E-01	6.7059E-01	9.9859E-01	1.4167E+02	1.3159E-01
1.0000E+00	2.4634E-01	2.4863E-01	0.	4.5903E-02	1.5477E-01	0.	0.	1.4876E+02	1.1769E-01

CPTI=3.9961E-01 CPSI=5.0232E-01 ETAI=7.9354E-01 CTSI=5.3356E-01 CTSI/CPSI=1.2146E+00
CPT=3.8909E-01 CPS=5.9114E-01 ETA=6.6783E-01 CTS=4.9521E-01 CTS/CPS=8.5395E-01

X	CL	ALI(DEG)	FM/C	CD/CL	F(X)	LI(LBF/FT)	TETS(DEG)	(C/R0)LE	(C/R0)TE	T/R0
1.760E-01	0.	0.	0.	0.	0.	0.	0.	-2.292E-01	2.292E-01	9.901E-02
2.500E-01	3.524E-01	5.476E-01	2.393E-02	3.068E-02	2.637E-01	3.270E+03	-3.200E+00	-2.822E-01	2.449E-01	9.423E-02
3.000E-01	3.237E-01	4.939E-01	2.179E-02	3.188E-02	2.154E-01	4.558E+03	-4.011E+00	-3.122E-01	2.589E-01	9.073E-02
4.000E-01	2.412E-01	3.714E-01	1.578E-02	3.959E-02	2.232E-01	5.374E+03	0.	-3.178E-01	3.179E-01	8.135E-02
5.000E-01	1.854E-01	2.856E-01	1.259E-02	4.922E-02	2.297E-01	9.737E+03	1.031E+01	-2.353E-01	4.406E-01	6.887E-02
6.000E-01	1.527E-01	2.352E-01	1.137E-02	5.786E-02	2.300E-01	1.026E+04	2.166E+01	-9.468E-02	5.956E-01	5.494E-02
7.000E-01	1.318E-01	2.030E-01	9.952E-03	6.541E-02	2.333E-01	1.146E+04	3.272E+01	9.681E-02	7.683E-01	4.103E-02
8.000E-01	1.171E-01	1.803E-01	7.951E-03	7.235E-02	2.476E-01	1.195E+04	4.498E+01	3.692E-01	9.755E-01	2.880E-02
9.000E-01	1.057E-01	1.628E-01	7.177E-03	7.944E-02	2.501E-01	1.347E+04	5.456E+01	6.578E-01	1.145E+00	1.919E-02
9.500E-01	1.035E-01	1.547E-01	6.823E-03	8.395E-02	2.528E-01	9.445E+03	5.775E+01	9.196E-01	1.186E+00	1.584E-02
1.000E+00	0.	0.	0.	0.	0.	0.	6.003E+01	1.092E+00	1.097E+00	0.

ETAD=7.1467E-01 PS(HP) =2.9985E+04 1-THO=8.3700E-01 1-WTT=7.6510E-01 V(KNOTS) =2.4250E+01 DESIGN TH(LB)=3.4393E+05
Z= 5 N(REV/MIN)=1.2000E+02 AE/AO=7.6683E-01 V(FT/SEC) =4.0942E+01 CALCULATED TH(LBF)=3.4393E+05

X	AREA (IN2)	XBAR (IN)	YBAR (IN)	IXO (IN4)	IYO (IN4)	MXO (IN-LBF)	MYO (IN-LBF)	MTB (IN-LBF)	MOB (IN-LBF)	MAXSTRESS (LBF/IN2)
1.760E-01	6.232E+02	2.992E+01	0.	6.839E+03	1.411E+05	-3.313E+06	6.228E+05	4.[illegible]E+06	2.254E+06	3.903E+03
3.000E-01	7.113E+02	3.727E+01	1.197E-01	6.553E+03	2.499E+05	-4.331E+06	1.022E+07	3.456E+06	1.535E+06	3.506E+03
4.000E-01	7.098E+02	4.148E+01	9.231E-02	5.259E+03	[illegible]E+05	-3.409E+07	-5.260E+06	2.779E+06	1.187E+06	5.358E+03
5.000E-01	6.391E+02	4.411E+01	5.627E-02	3.393E+03	3.146E+05	-2.740E+07	-2.837E+06	1.792E+06	9.318E+05	2.909E+04
6.000E-01	5.207E+02	4.505E+01	2.877E-02	1.760E+03	2.674E+05	-2.434E+07	-3.629E+06	1.125E+06	4.994E+05	3.449E+04
7.000E-01	3.795E+02	4.397E+01	0.	7.151E+02	1.856E+05	-8.493E+06	1.405E+06	5.965E+05	2.533E+05	3.320E+03
8.000E-01	2.433E+02	4.016E+01	0.	2.259E+02	9.931E+04	-2.742E+06	6.309E+05	2.4[illegible]1E+05	9.908E+04	1.631E+04

X	RAKG/D	PI XTANPI	PI XTANB
1.760E-01	0.	6.560E-01	3.879E-01
2.500E-01	0.	6.986E-01	4.399E-01
3.000E-01	0.	7.397E-01	4.917E-01
4.000E-01	-1.079E-01	9.099E-01	5.917E-01
5.000E-01	-1.004E-01	8.611E-01	6.692E-01
6.000E-01	-5.761E-01	8.833E-01	7.031E-01
7.000E-01	-8.461E-01	8.967E-01	7.247E-01
8.000E-01	-1.050E+00	9.099E-01	7.451E-01
9.000E-01	-1.152E+00	9.279E-01	7.677E-01
9.500E-01	-1.140E+00	9.272E-01	7.749E-01
1.000E+00	-1.122E+00	9.310E-01	7.011E-01

WEIGHT OF BLADES(LBF)= 73852.0224

WEIGHT OF PROP (BLADES + CYLINDRICAL HUB)(LBF)= 99858.5588

CENTER OF GRAVITY OF PROP REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD. + AFT)/D= -.221399

CENTER OF GRAVITY OF BLADES REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD. + AFT)/D= -.295965

HUB DIMENSIONS/D
HUB DIAM = .1769
HUB LENGTH = .1759
MIDCHORD OF ROOT SECTION TO AFT END OF HUB = .0888

KELLERS MINIMUM EAR= .7090E+00

SPEED COEFF V/(ND) JS= .8990E+00

ADVANCE COEFF V(1-WTT)/(ND) JA= .6937E+00

DESIGN THRUST COEFF KT= .1544E+00

TORQUE COEFF KQ= .2561E-01

PROPULSIVE EFFICIENCY ETAO= .7147E+00

BURRILL THRUST COEFF TC= .1113E+00

BURRILL CAVITATION COEFF SIGMA(0.7)= .2952E+00

CLEARANCE AT HUB BETWEEN BLADES/D= 4.5939E-02

CLEARANCE AT HUB BETWEEN FILLETS/D= -1.2432E-02

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MASS POLAR MOMENT OF INERTIA OF BLADES (LBM-IN2)=  .316516E+09

TOTAL MASS POLAR MOMENT OF INERTIA (LBM-IN2)=  .316515E+09

RADIUS OF GYRATION OF BLADE/D=    .2372

RADIUS OF GYRATION OF HUB/D=   0.0000

TOTAL RADIUS OF GYRATION/D=    .2049


         ABS COEFFICIENTS (CALCULATED AT THE .25 RADIUS)

ABS MINIMUM THICKNESS IN INCHES (USING P/D=PIXTANBI)-
                    USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.4040E-01
                    USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.4048E-01

VALUES USED IN DETERMINING THICKNESS-      A=  .105049E+02
                                           B=  .393942E+03
                                           C=  .119636E+05

SECTION AREA COEFFICIENT      CS=  .6942E+00

SECTION MODULUS COEFFICIENT      CN=  .8558E-01

AREA OF EXPANDED CYLINDRICAL SECTION IN SQ.INCHES      AS= .6565E+03



FOR CN=.1
ABS MINIMUM THICKNESS IN INCHES (USING P/D=PIXTANBI)-
                    USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.3220E-01
                    USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.3220E-01
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RADIAL PROPELLER DATA FOR INPUT INTO DESIGN PROGRAMS(8 RADIAL STRIPS ASSUMED)

X*	TAN BETA I	G	XSL(INCHES)	XST(INCHES)	1-WX	UA/2VS	THICKNESS(INCHES)
.22750	.95541	.1164E-01	-34.67850	33.17629	.47193	.1319E+00	13.28320
.27900	.72261	.1603E-01	-41.55359	34.79276	.52733	.1527E+00	12.73339
.38200	.65497	.1857E-01	-44.60714	41.75564	.64531	.1670E+00	11.49301
.48500	.56125	.1839E-01	-34.75714	57.89128	.74291	.1643E+00	9.78009
.58800	.47715	.1890E-01	-15.72538	79.40378	.79656	.1645E+00	7.91693
.69100	.41256	.1841E-01	10.28830	103.65865	.91214	.1651E+00	5.82775
.79400	.35444	.1699E-01	47.38353	132.94599	.93678	.1676E+00	4.06706
.89700	.32741	.1357E-01	99.62237	157.35951	.86194	.1577E+00	2.66102
.94850	.31113	.1031E-01	112.26229	163.79477	.87029	.1562E+00	2.21470
1.00000			159.72516	159.72516			

DOCUMENTATION CASE A

PS(HP)= 3.0000E+04, DENSITY OF PROP(LBM/FT3)= 483.8400

V(KNOTS)	2.3500E+01	2.4000E+01	2.4500E+01	2.4700E+01	2.5000E+01
PE(HP)	1.9329E+04	2.0756E+04	2.2246E+04	2.3052E+04	2.4777E+04

D(FT)= 23.0000 ,1-WTT=.7950 ,1-THO=.8370 ,H(FT)= 52.0000 ,RHO(SLUG/FT3)= 1.9905

Z	6	5	
AE/AO	7.6483E-01	7.6800E-01	9.0000E-01
N(REV/MIN)	1.0600E+02	1.2000E+02	

X INPUT	1-WX INPUT	C/D ADJUSTED	T/C INPUT	TANBI LERBS	TANB CALCULATED	TETS(DEG) NONLINEAR	RAKG/D NONLINEAR	P/D PIXTANBI	CD CALCULATED
1.7600E-01	4.3590E-01	2.6971E-01	2.1600E-01	1.2665E+00	8.3210E-01	0.	0.	0.	1.2337E-02
2.5000E-01	4.9410E-01	3.1029E-01	1.7800E-01	9.4939E-01	6.4022E-01	-3.2000E+00	0.	0.	1.0810E-02
3.0000E-01	5.5250E-01	3.3593E-01	1.5900E-01	8.3650E-01	5.9559E-01	-4.0117E+00	0.	0.	1.0227E-02
4.0000E-01	6.6420E-01	3.7392E-01	1.2800E-01	6.8798E-01	5.3799E-01	0.	-1.0703E-01	0.	9.5404E-03
5.0000E-01	7.5080E-01	3.9764E-01	1.0190E-01	5.8514E-01	4.8642E-01	1.0313E+01	-1.0344E-01	0.	9.1260E-03
6.0000E-01	7.9090E-01	4.0611E-01	7.9600E-02	5.0019E-01	4.2651E-01	2.1659E+01	-5.7609E-01	0.	8.8361E-03
7.0000E-01	8.1420E-01	3.9637E-01	6.0900E-02	4.3525E-01	3.7679E-01	3.2716E+01	-8.4659E-01	0.	8.6220E-03
8.0000E-01	8.3830E-01	3.6206E-01	4.6900E-02	3.8644E-01	3.7944E-01	4.4977E+01	-1.0530E+00	0.	8.4723E-03
9.0000E-01	9.6250E-01	2.9651E-01	3.9400E-02	3.4842E-01	3.1944E-01	5.4546E+01	-1.1572E+00	0.	8.3964E-03
9.5000E-01	9.7050E-01	2.1576E-01	4.3200E-02	3.3161E-01	2.9692E-01	5.7754E+01	-1.1400E+00	0.	8.4355E-03
1.0000E+00	9.7760E-01	0.	0.	3.1631E-01	2.9429E-01	6.0000E+01	-1.1217E+00	0.	8.0000E-03

X	TANBI	TAN B	G	UT/2V	UA/2V	DCTSI	DCPSI	VP(FT/SEC)	CAVV
1.7600E-01	1.3704E+00	7.9587E-01	0.	1.7529E-01	7.4456E-02	0.	0.	2.5914E+01	4.1925E+00
2.5000E-01	1.0273E+00	6.3524E-01	1.4758E-02	1.7366E-01	1.2652E-01	1.7832E-01	1.4248E-01	3.5537E+01	2.3345E+00
3.0000E-01	9.0524E-01	5.9194E-01	1.7882E-02	1.6309E-01	1.4490E-01	2.7549E-01	2.3277E-01	4.2631E+01	1.6421E+00
4.0000E-01	7.4440E-01	5.3371E-01	2.0742E-02	1.3592E-01	1.6111E-01	4.5992E-01	4.2637E-01	5.6708E+01	9.3065E-01
5.0000E-01	6.3315E-01	4.8264E-01	2.1683E-02	1.1175E-01	1.6746E-01	6.2446E-01	6.1703E-01	7.0152E+01	6.3004E-01
6.0000E-01	5.4123E-01	4.2320E-01	2.1976E-02	9.5307E-02	1.6972E-01	7.7955E-01	7.8659E-01	8.2641E+01	4.2318E-01
7.0000E-01	4.7396E-01	3.7385E-01	2.1537E-02	8.3513E-02	1.7216E-01	8.9214E-01	9.2532E-01	9.4994E+01	3.1269E-01
8.0000E-01	4.1814E-01	3.3680E-01	1.9829E-02	7.3192E-02	1.7196E-01	9.5807E-01	9.9712E-01	1.0744E+02	2.3824E-01
9.0000E-01	3.7701E-01	3.0802E-01	1.5750E-02	6.4202E-02	1.6997E-01	9.6184E-01	9.0982E-01	1.1997E+02	1.8605E-01
9.5000E-01	3.5882E-01	2.9452E-01	1.1811E-02	6.3696E-02	1.6929E-01	5.8388E-01	7.2530E-01	1.2628E+02	1.6584E-01
1.0000E+00	3.4227E-01	2.8207E-01	0.	5.7537E-02	1.6759E-01	0.	0.	1.3243E+02	1.4050E-01

CPTI=4.0128E-01 CPSI=5.1380E-01 ETAI=7.8120E-01 CTSI=5.1192E-01 CTSI/CPSI=9.9639E-01
CPT=3.9016E-01 CPS=5.7743E-01 ETA=6.7560E-01 CTS=4.9572E-01 CTS/CPS=8.6022E-01

X	CL	ALI(DEG)	FM/C	CD/CL	F(X)	LI(LBF/FT)	TETS(DEG)	(C/RO)LE	(C/RO)TE	T/RO
1.760E-01	0.	0.	0.	0.	0.	0.	0.	-2.697E-01	2.697E-01	1.165E-01
2.500E-01	3.452E-01	5.317E-01	2.344E-02	3.134E-02	1.891E-01	3.395E+03	-3.200E+00	-3.301E-01	2.981E-01	1.109E-01
3.000E-01	3.219E-01	4.957E-01	2.188E-02	3.137E-02	2.007E-01	4.439E+03	-4.011E+00	-3.643E-01	3.075E-01	1.068E-01
4.000E-01	2.522E-01	3.893E-01	1.712E-02	3.786E-02	2.102E-01	5.361E+03	0.	-3.739E-01	3.739E-01	9.572E-02
5.000E-01	2.004E-01	3.086E-01	1.361E-02	4.555E-02	2.167E-01	9.376E+03	1.031E+01	-2.911E-01	5.042E-01	8.104E-02
6.000E-01	1.698E-01	2.600E-01	1.146E-02	5.236E-02	2.186E-01	1.372E+04	2.166E+01	-1.402E-01	6.643E-01	6.465E-02
7.000E-01	1.475E-01	2.271E-01	1.001E-02	5.847E-02	2.213E-01	1.327E+04	3.277E+01	4.544E-02	8.382E-01	4.828E-02
8.000E-01	1.314E-01	2.024E-01	8.923E-03	6.447E-02	2.268E-01	1.257E+04	4.498E+01	3.196E-01	1.043E+00	3.389E-02
9.000E-01	1.181E-01	1.819E-01	8.021E-03	7.105E-02	2.332E-01	1.115E+04	5.455E+01	6.292E-01	1.207E+00	2.258E-02
9.500E-01	1.119E-01	1.722E-01	7.593E-03	7.543E-02	2.343E-01	9.796E+03	5.775E+01	9.016E-01	1.233E+00	1.864E-02
1.000E+00	0.	0.	0.	0.	0.	0.	6.000E+01	1.107E+00	1.107E+00	0.

ETAD=7.2071E-01 PS(HP) =2.9986E+04 1-THO=8.3700E-01 1-WTT=7.9500E-01 V(KNOTS) =2.4318E+01 DESIGN TH(LBF)=3.4577E+05
Z= 5 N(REV/MIN)=1.0600E+02 INPUT AE/AO=9.0000E-01 V(FT/SEC) =4.1030E+01 CALCULATED TH(LBF)=3.4576E+05

X	AREA (IN2)	XBAR (IN)	YBAR (IN)	IXO (IN4)	IYO (IN4)	MXO (IN-LBF)	MYO (IN-LBF)	MTR (IN-LBF)	MOB (IN-LBF)	MAXSTRESS (LBF/IN2)
1.750E-01	9.629E+02	3.521E+01	0.	1.311E+04	2.706E+05	-2.293E+06	9.496E+05	4.702E+06	2.560E+06	2.249E+03
3.000E-01	9.849E+02	4.385E+01	1.477E-01	1.257E+04	4.792E+05	-4.977E+06	1.157E+07	3.533E+06	1.363E+06	2.515E+03
4.000E-01	9.829E+02	4.881E+01	1.071E-01	1.008E+04	5.925E+05	-3.509E+07	-7.312E+06	2.644E+06	1.356E+06	3.312E+03
5.000E-01	8.849E+02	5.191E+01	7.431E-02	6.555E+03	6.032E+05	-2.435E+07	-4.274E+06	1.941E+06	9.156E+05	1.829E+04
6.000E-01	7.210E+02	5.301E+01	3.759E-02	3.374E+03	5.127E+05	-2.627E+07	-5.231E+06	1.156E+06	5.583E+05	2.220E+04
7.000E-01	5.255E+02	5.174E+01	0.	1.371E+03	3.559E+05	-6.977E+06	1.147E+06	6.130E+05	2.877E+05	2.214E+03
8.000E-01	3.369E+02	4.726E+01	0.	4.331E+02	1.904E+05	-2.437E+06	5.827E+05	2.464E+05	1.122E+05	1.087E+04

X	RAKG/D	PI XTANPI	PI XTANB
1.760E-01	0.	7.577E-01	4.401E-01
2.500E-01	0.	9.068E-01	4.989E-01
3.000E-01	0.	9.572E-01	5.579E-01
4.000E-01	-1.079E-01	9.354E-01	6.707E-01
5.000E-01	-1.094E-01	9.946E-01	7.591E-01
6.000E-01	-5.761E-01	1.020E+00	7.977E-01
7.000E-01	-9.451E-01	1.036E+00	8.221E-01
8.000E-01	-1.059E+00	1.051E+00	9.465E-01
9.000E-01	-1.152E+00	1.066E+00	9.709E-01
9.500E-01	-1.140E+00	1.071E+00	9.791E-01
1.000E+00	-1.122E+00	1.075E+00	9.962E-01

WEIGHT OF BLADES(LBF)= 102252.1559

WEIGHT OF PROP (BLADES + CYLINDRICAL HUB)(LBF)= 127468.6926

CENTER OF GRAVITY OF PROP REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= -.235836

CENTER OF GRAVITY OF BLADES REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D= -.293967

HUB DIMENSIONS/D   HUB DIAM = .1762
HUB LENGTH = .1760
MIDCHORD OF ROOT SECTION TO AFT END OF HUB = .0880

KELLERS MINIMUM EAR= .7039E+00

SPEED COEFF V/(ND) JS= .1010E+01

ADVANCE COEFF V(1-WTT)/(ND) JA= .7927E+00

DESIGN THRUST COEFF KT= .1989E+00

TORQUE COEFF KQ= .3716E-01

PROPULSIVE EFFICIENCY ETAD= .7200E+00

BURRILL THRUST COEFF TC= .1230E+00

BURRILL CAVITATION COEFF SIGMA(0.7)= .3680E+00

CLEARANCE AT HUB BETWEEN BLADES/D= 3.8466E-02

CLEARANCE AT HUB BETWEEN FILLETS/D= -2.6440E-02

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MASS POLAR MOMENT OF INERTIA OF BLADES (LBM-IN2)=  .439277E+09

TOTAL MASS POLAR MOMENT OF INERTIA (LBM-IN2)=  .439277E+09

RADIUS OF GYRATION OF BLADE/D=    .2372

RADIUS OF GYRATION OF HUB/D=   0.0000

TOTAL RADIUS OF GYRATION/D=    .2125


         ABS COEFFICIENTS (CALCULATED AT THE .25 RADIUS)

ABS MINIMUM THICKNESS IN INCHES (USING P/D=PIXTANBT)-
                   USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.2175E-01
                   USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.2175E-01

VALUES USED IN DETERMINING THICKNESS-      A=  .102525E+02
                                           B=  .357117E+03
                                           C=  .152495E+05

SECTION AREA COEFFICIENT     CS=  .5942E+00

SECTION MODULUS COEFFICIENT     CN=  .8558E-01

AREA OF EXPANDED CYLINDRICAL SECTION IN SQ.INCHES     AS= .9991E+03



FOR CN=.1
ABS MINIMUM THICKNESS IN INCHES (USING P/D=PIXTANBT)-
                   USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.1644E-01
                   USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.1644E-01
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RADIAL PROPELLER DATA FOR INPUT INTO DESIGN PROGRAMS(9 RADIAL STRIPS ASSUMED)

XR	TAN BETA I	G	XSL(INCHES)	XST(INCHES)	1-WY	UA/2VS	THICKNESS(INCHES)
.22750	1.10464	.1203E-01	-42.98523	39.16093	.47103	.1145E+00	15.53658
.27900	.95309	.1692E-01	-49.57019	41.31972	.52733	.1383E+00	14.98354
.39200	.76303	.2044E-01	-52.30850	49.31795	.64531	.1596E+00	13.52415
.49580	.64924	.2160E-01	-42.49033	66.53171	.74091	.1635E+00	11.58852
.58830	.55110	.2197E-01	-23.16773	88.87938	.78656	.1692E+00	9.19940
.69100	.47659	.2162E-01	3.40571	113.27733	.91214	.1720E+00	5.85768
.79400	.42072	.1999E-01	41.54590	142.29553	.83679	.1720E+00	4.78502
.89730	.37915	.1598E-01	85.61917	165.31597	.85196	.1690E+00	3.13130
.94850	.35935	.1291E-01	109.73544	170.24077	.87029	.1693E+00	2.60618
1.00000			152.74154	152.74154			

DOCUMENTATION CASE A

PS(HP)= 3.0000E+04, DENSITY OF PROP(LBM/FT3)= 493.8400

V(KNOTS)	2.3500E+01	2.4000E+01	2.4500E+01	2.4700E+01	2.5000E+01
PE(HP)	1.9329E+04	2.0756E+04	2.2246E+04	2.3059E+04	2.4277E+04

D(FT)= 23.0000 ,1-WTT=.7450 ,1-THD=.8370 ,H(FT)= 52.0000 ,RHO(SLUG/FT3)= 1.9905

Z	6	5	
AE/A0	7.6483E-01	7.6800E-01	9.0000E-01
N(REV/MIN)	1.0600E+02	1.2000E+02	

X INPUT	1-WY INPUT	C/D ADJUSTED	T/C INPUT	TANBI LEPBS	TANB CALCULATED	TETS(DEG) NONLINEAR	RAKG/D NONLINEAR	P/D PIXTANBI	CD CALCULATED
1.7600E-01	4.3590E-01	2.6971E-01	2.1600E-01	1.1197E+00	7.0952E-01	0.	0.	0.	1.2337E-02
2.5000E-01	4.9410E-01	3.1009E-01	1.7880E-01	8.3942E-01	5.6553E-01	-3.2000E+00	0.	0.	1.0010E-02
3.0000E-01	5.5250E-01	3.3593E-01	1.5890E-01	7.3890E-01	5.7599E-01	-4.0110E+00	0.	0.	1.0227E-02
4.0000E-01	6.6420E-01	3.7392E-01	1.2900E-01	5.0759E-01	4.7514E-01	0.	-1.0793E-01	0.	9.5484E-03
5.0000E-01	7.5990E-01	3.9744E-01	1.0190E-01	5.1699E-01	4.2967E-01	1.0313E+01	-1.2044E-01	0.	9.1268E-03
6.0000E-01	7.9000E-01	4.0611E-01	7.9600E-02	4.4193E-01	3.7675E-01	2.1658E+01	-5.7609E-01	0.	8.8361E-03
7.0000E-01	8.1420E-01	3.9617E-01	6.0900E-02	3.8447E-01	3.3992E-01	3.2716E+01	-8.4609E-01	0.	8.6220E-03
8.0000E-01	8.3870E-01	3.5706E-01	4.6800E-02	3.4139E-01	2.7994E-01	4.4977E+01	-1.0530E+00	0.	8.4728E-03
9.0000E-01	8.6250E-01	2.8551E-01	3.9400E-02	3.0777E-01	2.7422E-01	5.4546E+01	-1.1922E+00	0.	8.3964E-03
9.5000E-01	8.7050E-01	2.1576E-01	4.3200E-02	2.9292E-01	2.6220E-01	5.7754E+01	-1.1430E+00	0.	8.4355E-03
1.0000E+00	8.7760E-01	0.	0.	2.7941E-01	2.5112E-01	6.0000E+01	-1.1217E+00	0.	8.8000E-03

X	TANBI	TAN 0	G	UT/2V	UA/2V	DCTSI	DCPSI	VR(FT/SEC)	CAVV
1.7600E-01	1.1736E+00	6.9410E-01	0.	1.7694E-01	9.3536E-02	0.	0.	2.8171E+01	3.5870E+00
2.5000E-01	8.7977E-01	5.5402E-01	1.4149E-02	1.6646E-01	1.4409E-01	2.0527E-01	1.6106E-01	3.9138E+01	1.9408E+00
3.0000E-01	7.7526E-01	5.1625E-01	1.6745E-02	1.5229E-01	1.5913E-01	3.0741E-01	2.5536E-01	4.7050E+01	1.3565E+00
4.0000E-01	6.3752E-01	4.6547E-01	1.8634E-02	1.2131E-01	1.6917E-01	4.8559E-01	4.4266E-01	6.2725E+01	7.6301E-01
5.0000E-01	5.4224E-01	4.2092E-01	1.9859E-02	9.5563E-02	1.6459E-01	6.3573E-01	6.1545E-01	7.7792E+01	4.9866E-01
6.0000E-01	4.6352E-01	3.6958E-01	1.8734E-02	7.3952E-02	1.6527E-01	7.7234E-01	7.6596E-01	9.2030E+01	3.4173E-01
7.0000E-01	4.0334E-01	3.2535E-01	1.9129E-02	6.4735E-02	1.6533E-01	8.8344E-01	8.9991E-01	1.0608E+02	2.5083E-01
8.0000E-01	3.5911E-01	2.9374E-01	1.6732E-02	5.9262E-02	1.6245E-01	9.3519E-01	9.5577E-01	1.2029E+02	1.9022E-01
9.0000E-01	3.2288E-01	2.6964E-01	1.3375E-02	5.1272E-02	1.5763E-01	8.4516E-01	9.7614E-01	1.3449E+02	1.4805E-01
9.5000E-01	3.0730E-01	2.5685E-01	1.0085E-02	4.9295E-02	1.5613E-01	6.7397E-01	7.0190E-01	1.4158E+02	1.3176E-01
1.0000E+00	2.9312E-01	2.4601E-01	0.	4.5495E-02	1.5475E-01	0.	0.	1.4087E+02	1.1783E-01

CPTI=4.0052E-01	CPSI=5.0463E-01	ETAI=7.9369E-01	CTSI=5.1272E-01	CTSI/CPSI=1.0150E+00
CPT=3.8901E-01	CPS=6.0035E-01	ETA=6.4631E-01	CTS=4.9673E-01	CTS/CPS=8.2657E-01

X	CL	ALI(DEG)	FW/C	CD/CL	F(X)	LT(LBF/FT)	TETS(DEG)	(C/RO)LE	(C/RO)TE	T/RO
1.760E-01	0.	0.	0.	0.	0.	0.	0.	-2.697E-01	2.697E-01	1.165E-01
2.500E-01	2.967E-01	4.570E-01	2.015E-02	3.643E-02	1.774E-01	3.225E+03	-3.200E+00	-3.297E-01	2.915E-01	1.109E-01
3.000E-01	2.696E-01	4.153E-01	1.931E-02	3.793E-02	1.893E-01	4.579E+03	-4.011E+00	-3.625E-01	3.094E-01	1.068E-01
4.000E-01	2.022E-01	3.114E-01	1.373E-02	4.722E-02	1.957E-01	5.919E+03	0.	-3.739E-01	3.739E-01	9.572E-02
5.000E-01	1.552E-01	2.390E-01	1.054E-02	5.881E-02	2.000E-01	9.549E+03	1.031E+01	-2.953E-01	5.000E-01	8.104E-02
6.000E-01	1.276E-01	1.965E-01	8.666E-03	6.923E-02	2.012E-01	1.034E+04	2.166E+01	-1.561E-01	6.561E-01	6.465E-02
7.000E-01	1.131E-01	1.696E-01	7.477E-03	7.831E-02	2.042E-01	1.174E+04	3.272E+01	3.462E-02	8.274E-01	4.828E-02
8.000E-01	9.742E-02	1.506E-01	6.642E-03	8.672E-02	2.129E-01	1.172E+04	4.498E+01	3.050E-01	1.023E+00	3.389E-02
9.000E-01	8.835E-02	1.361E-01	5.999E-03	9.5? E-02	2.198E-01	1.349E+04	5.455E+01	6.139E-01	1.197E+00	2.258E-02
9.500E-01	8.403E-02	1.294E-01	5.735E-03	1.004E-01	2.224E-01	9.119E+03	5.775E+01	7.960E-01	1.219E+00	1.864E-02
1.000E+00	0.	0.	0.	0.	0.	0.	6.000E+01	1.091E+00	1.091E+00	0.

ETAD=6.9194E-01 PS(HP) =3.0005E+04 1-THD=8.3700E-01 1-WTT=7.6370E-01 V(KNOTS) =2.4001E+01 DESIGN TH(LBF)=3.3673E+05
Z= 5 N(REV/MIN)=1.2000E+02 INPUT AE/A0=9.0310E-01 V(FT/SEC) =4.0509E+01 CALCULATED TH(LBF)=3.3673E+05

X	AREA (IN2)	XBAR (IN)	YBAR (IN)	IXO (IN4)	IYO (IN4)	MYO (IN-LBF)	MYC (IN-LBF)	MTR (IN-LBF)	MOB (IN-LBF)	MAXSTRESS (LBF/IN2)
1.760E-01	8.629E+02	3.521E+01	0.	1.311E+04	2.706E+05	-6.517E+05	-5.179E+04	4.519E+06	2.258E+06	3.902E+03
3.000E-01	9.849E+02	4.385E+01	1.191E-01	1.257E+04	4.792E+05	-7.111E+06	1.372E+07	3.391E+06	1.640E+06	3.656E+03
4.000E-01	9.829E+02	4.891E+01	8.094E-02	1.075E+04	5.925E+05	-4.945E+07	-7.313E+06	2.523E+06	1.193E+06	4.520E+03
5.000E-01	9.849E+02	5.191E+01	5.531E-02	6.505E+03	5.072E+05	-3.327E+07	-3.899E+05	1.753E+06	9.072E+05	2.481E+04
6.000E-01	7.219E+02	5.301E+01	2.832E-02	3.374E+03	5.127E+05	-3.406E+07	-4.929E+06	1.100E+06	4.937E+05	2.964E+04
7.000E-01	5.255E+02	5.174E+01	0.	1.371E+03	3.559E+05	-1.294E+07	1.976E+06	5.936E+05	2.558E+05	2.109E+03
8.000E-01	3.369E+02	4.726E+01	0.	4.331E+02	1.904E+05	-3.351E+05	9.939E+05	2.350E+05	1.003E+05	1.429E+04

X	RAKG/D	PI XTANRI	PI XTANP
1.760E-01	0.	6.499E-01	3.939E-01
2.500E-01	0.	6.910E-01	4.351E-01
3.000E-01	0.	7.307E-01	4.864E-01
4.000E-01	-1.078E-01	8.011E-01	5.949E-01
5.000E-01	-1.034E-01	8.518E-01	6.612E-01
6.000E-01	-5.761E-01	8.737E-01	6.957E-01
7.000E-01	-9.461E-01	8.870E-01	7.170E-01
8.000E-01	-1.350E+00	9.000E-01	7.382E-01
9.000E-01	-1.152E+00	9.129E-01	7.595E-01
9.500E-01	-1.140E+00	9.171E-01	7.665E-01
1.000E+00	-1.122E+00	9.209E-01	7.728E-01

WEIGHT OF BLADES(LBF)= 182262.1568

WEIGHT OF PROP (BLADES + CYLINDRICAL HUB)(LBF)= 127468.6926

CENTER OF GRAVITY OF PROP REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD. + AFT)/D= -.238975

CENTER OF GRAVITY OF BLADES REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD. + AFT)/D= -.297888

HUB DIMENSIONS/D   HUB DIAM = .1760
HUB LENGTH = .1768
MIDCHORD OF ROOT SECTION TO AFT END OF HUB = .0888

KELLERS MINIMUM EAR= .6884E+00

SPEED COEFF V/(ND) JS= .8806E+00

ADVANCE COEFF V(1-WTT)/(ND) JA= .6913E+00

DESIGN THRUST COEFF KT= .1511E+00

TORQUE COEFF KQ= .2563E-01

PROPULSIVE EFFICIENCY ETAD= .6918E+00

BURRILL THRUST COEFF TC= .9252E-01

BURRILL CAVITATION COEFF SIGMA(0.7)= .2958E+00

CLEARANCE AT HUB BETWEEN BLADES/D= 3.4048E-02

CLEARANCE AT HUB BETWEEN FILLETS/D= -3.4834E-02

```
MASS POLAR MOMENT OF INERTIA OF BLADES (LBM-IN2)=  .438277E+09

TOTAL MASS POLAR MOMENT OF INERTIA (LBM-IN2)=  .438277E+09

RADIUS OF GYRATION OF BLADE/D=    .2372

RADIUS OF GYRATION OF HUB/D=   0.0000

TOTAL RADIUS OF GYRATION/D=    .2125


         ABS COEFFICIENTS (CALCULATED AT THE .25 RADIUS)

ABS MINIMUM THICKNESS IN INCHES (USING P/D=PIXTAN3T)-
                    USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.4332E-01
                    USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.4332E-01

VALUES USED IN DETERMINING THICKNESS-      A=  .107356E+02
                                           B=  .457679E+03
                                           C=  .139927E+05

SECTION AREA COEFFICIENT     CS=  .5942E+00

SECTION MODULUS COEFFICIENT     CN=  .8558E-01

AREA OF EXPANDED CYLINDRICAL SECTION IN SQ.INCHES     AS= .9091E+03



FOR CN=.1
ABS MINIMUM THICKNESS IN INCHES (USING P/D=PIXTAN3T)-
                    USING ABS RAKE = CONVENTIONAL RAKE,  T/D= -.3499E-01
                    USING ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= -.3489E-01
```

RADIAL PROPELLER DATA FOR INPUT INTO DESIGN PROGRAMS(8 RADIAL STRIPS ASSUMED)

XP	TAN BETA I	G	XSL(INCHES)	XST(INCHES)	1-WX	UA/2VS	THICKNESS(INCHES)
.22750	.94603	.1164E-01	-42.93938	39.31447	.47193	.1331E+00	15.53658
.27900	.81369	.1630E-01	-49.29510	41.55333	.52733	.1541E+00	14.99364
.34220	.65775	.1849E-01	-52.23388	49.39156	.64531	.1583E+00	13.52415
.49500	.55515	.1896E-01	-42.97390	66.04914	.74091	.1650E+00	11.50352
.58890	.47197	.1977E-01	-24.23320	97.94731	.78656	.1650E+00	9.19940
.69100	.40808	.1926E-01	1.94913	111.91945	.81214	.1654E+00	6.95768
.79430	.36049	.1695E-01	39.68365	140.39438	.83678	.1627E+00	4.78582
.89730	.32385	.1348E-01	83.50945	163.27621	.96196	.1577E+00	3.13139
.94850	.30775	.1025E-01	107.58506	158.11999	.97029	.1562E+00	2.68610
1.00000			150.59372	150.59372			

APPENDIX F

FORTRAN LISTING OF COMPUTER PROGRAM

```
      PROGRAM GMAIN(INPUT=256,OUTPUT=512, TAPE5=INPUT,TAPE6=OUTPUT)
      DIMENSION CHORD(11),THICKNS(11),CAMBER(11),PITCH(11),SKEWR(11)
     1 ,X(11),BT(11)
      DIMENSION B(38,38),DENS(6),B2(181),B3(181)
     1 ,B11(181),B14(181)
     2     ,B15(181),AZ(11,11),BH(11,11),C(12,12),CC(12,12)
      DIMENSION X3(11),X4(11),X5(11),X6(11),VEL(9),EHP(9),BLA(9),EXX(9)
      DIMENSION AZZ(11,38),ASHP(9),XMM(9),CAV(9),CAE(9),FX(11),BBJ(11)
      DIMENSION VEL1(9),EHP1(9),AX(11),RAK(11),PXTBI(11),PXTB(11),SX(7)
      DIMENSION VSUBRSQ(11),VSUBR(11)
      DIMENSION AREA(7),XBAR(7),YBAR(7),AYEXO(7),AYEYO(7),EMXO(7),EMYO(7
     1),EMTB(7),EMOB(7),STRMAX(7)
      DIMENSION W(13),FMMX(13),YTX(13),TX(11),CX(11),FMX(11),JBL(11),
     1          ARPHI(11),PMOX(11) ,R(13),S(13),P(13)
      DIMENSION TABS(6)
      DIMENSION DMV(9),DME(9),DMX(9)
      COMMON /UNITS/ SI,UI,UO
      COMMON/CHEIGHT/X,CHORD,THICKNS,CAMBER,PITCH,SKEWR,DIAM,ZZ,DEN,RAKE
     1,PI,PP7,PP8,PP9,PP11,EWAKE,VS,RPS,SIGMA,EAR,BT,R,POO
     2  ,FWDDIAM,AFTDIAM,HUBLEN,FDBORE,ADBORE,DISREFL
      COMMON B,   B2,B3,                          B11         ,B14,B15,AZ,BH,
     1C,CC,       ID,JB,JC,JD,JDD,JEE,CL1(11)
      COMMON CCONE(11),CCTWO(11),CCTHR(11),CCFOR(11)
      COMMON PP1,PP2,PP3,PP4,PP5,PP6,PP10
      COMMON SN(73),CO(73)
      DIMENSION XR(20),TANBETI(20),G(20),XSL(20),XST(20),WAKE(20)
     1,UVFLA(20),THICKP(20)
      DIMENSION TLES(10,2)
      REAL N,NI,INPUT,LERBS,LINR,NLINR
      DATA EAPU,EARF / 8H DESIGN  , 8H  INPUT  /
      DATA W /1.,4.,3.,8.,4.,8.,4.,8.,4.,8.,3.,4.,1./
      DATA FMMX /.0,.2712,.4482,.6993,.9635,.9515,1.,.9796,.8892,.7027,
     1 .3586,.1713,.0/
      DATA YTX  /.0,.2066,.2907,.4,.4637,.4952,.4962,.4653,.4035,.311,
     2 .1877,.1143,.0333/
      DATA DENS / 1.,521.856,1.,483.84,1.,1. /
      DATA  TABS /10HABS MINIMU ,10HM THICKNES ,10HS IN INCHE  ,
     2 10HS (USING P ,10H           ,10H           /
      DATATGS,UBS,VBS,XBS / 10H/D=PIXTANB ,10HI)-        ,
     2 10H/D INPUT)- ,10H           /
      DATA SHPP,SHPT1,SHPT2,DEN1,DEN2,DEN3,ZS,EARS,RPMS,COMMA,ADDJ
     1 /5H SHP=,7H THRUST,7H OPTION,10H, DENSITY ,10HOF PROP(LP,
     2  8HM/FT3)= ,3H Z=,5H EAR=,5H RPM=,2H, ,10H ADJUSTED  /
      DATA TLES / 10H    X       ,10H    1-WX      ,10H    C/D      ,
     2 10H   T/C        ,10H  TANBI       ,10H   TANB       ,
     3 10H TETS(DEG)    ,10H  RAKG/D  ,10H    P/D       ,
     4 10H    CD        , 10*1H  /
      DATA INPUT,LERBS,LINR,NLINR,PXTNBI,CONST,CALC /10H  INPUT       ,
     2 10H  LERBS      ,10H  LINEAR      ,10HNONLINEAR     ,
     3 10HPIXTANBI     ,10HCONSTANT      ,10HCALCULATED    /
      DATA SI /2HSI/
      DATA UVE / 7HFT/SEC)  /
      DATA EXA,URPM / 5HAE/A0   ,9H(REV/MIN)  /
      DATA UEI,UEF,USL /4H(IN) ,4H(FT) , 4H(M)  /
      DATA VL,PE / 2HV( , 3HPE( /
      DATA ULE,ULS / 8H(LBF/FT) , 8H(N/M)         /
      DATA USV,UEV / 6HM/SEC) ,6HKNOTS)  /
```

```
      DATA USP,UEP / 3HKW) , 3HHP) /
      DATA UED,USD / 10H(SLUG/FT3) ,10H(KG/M3)         /
      DATA ULE4,ULS4,ULE2,ULS2,UNM,UIL,UPA,UPIN2  /5H(IN4),5H(M4) ,
     * 5H(IN2),5H(M2) ,8H(N-M)     ,8H(IN-LBF),9H(PA)      ,9H(LBF/IN2) /
      DATA UFE,UFS / 5H(LBF) ,5H(N)     /
      DATA U02,U03 /10HOF PROP(KG,8H/M3)=   /
      DATA PMI,U07 /10H(LBM-IN2)= ,10H(KG-M2)=    /
      DATA GR1,GR2 / 9HRADIUS OF  ,9H GYRATION  /
      DATA EFT,U04 / 4HFT.=,4HM.=  /
      DATA EIN,U05 /5HINCH),5HM)     /
      DATA EINS,U06 /7HINCHES= ,7HMETERS= /
      DATA EAV,SIV /6H  RPM= ,6HRAD/S=   /
      DATA PINS,U08 / 7HINCHES) ,7HMETERS) /
      DATA PINS,U09 / 6HINCHES , 6HMETERS /
      DATA EFP,U10 /4HFT)= ,4HM)=  /
      ELI=1./.0254
      EL2=1./ELI/ELI
      FLF=1./.3048
      DSI=1./16.01846
      RHOSI=1./515.3788
      VSI=1./.5144444
      PHP=1000./745.6999
      SIM=1./.1129848
      UWT=1./4.44822
     JC=11
      DKTS=1.6878
     PI=3.14159265
      PI2=2.*PI
      DO 31 I=1,73
      AC=5.*(I-1)*2.*PI/360.
      SN(I)=SIN(AC)
   31 CO(I)=COS(AC)
      READ(5,*) IDD
     DO 10072 NDIA=1,IDD
      SPM=60./PI2
      READ(5,10008) UI,UO
      READ(5,*) SHP,TANBI,TANB,XPS,RAKE,PDO,CD,TYPE,HUB
      READ(5,*) DIAM,EWAKE,ETHRUS,HEAD,DEN,RHO
      READ(5,*) IVV,(VEL(I),I=1,IVV),(EHP(I),I=1,IVV),IZZ,
     1 (UBL(I),I=1,IZZ),IEA,  (EXX(I),I=1,IEA),IRPM, (XMM(I),I=1,IRPM)
      READ(5,*) (X3(I),I=1,JC),(X4(I),I=1,JC),(X5(I),I=1,JC),(X6(I),
     1 I=1,JC),(AZZ(I,25),I=1,JC)
      IF(XPS.LT.0.) READ(5,*) (AZZ(I,24),I=1,JC)
      IF(ABS(CD).GE.10.) READ(5,*)      (B(I,7),I=1,JC)
      IF(TANB.GT.0.) READ(5,*) (B(I,8),I=1,JC)
      IF(RAKE.GT.0..AND.RAKE.LE..01) READ(5,*) (RAK(I),I=1,JC)
      IF(PDO.GT.0.) READ(5,*) (P(I),I=1,JC)
      IF(HUB.NE.0.) READ(5,*) FWDDIAM,AFTDIAM,HUBLEN,FDBORE,ADBORE,
     1 DISPEFL
C
C     NO DATA READ ANYWHERE BEYOND THIS STATEMENT
C
      RF=DIAM
      IF(UI.NE.SI) RF=DIAM*12.
       IF(RAKE.GT.0..AND.RAKE.LE..01) GO TO 140
      RAKE=RAKE*RF
      GO TO 142
```

```
140   DO 141 I=1,JC
141   RAK(I)=RAK(I)*RF
142   UDEN=UED
      IDEN=DEN
      IF(IDEN.LT.2) IDEN=4
      IF(IDEN.LT.7) DEN=DENS(IDEN)
      UL=UEF
      VU=UEV
      PU=UEP
      IF(UI.NE.SI) GO TO 2413
      IF(IDEN.LT.7)  DEN=DEN/DSI
      UDEN=USD
      UL=USL
      VU=USV
      PU=USP
2413  WRITE(6,10046) IDD
      IF(SHP.EQ.0.) WRITE(6,10020) SHPT1,SHPT2,DEN1,DEN2,DEN3,DEN
      IF(SHP.NE.0.) WRITE(6,10021) PU,  SHP,DEN1,DEN2,DEN3,DEN
      WRITE(6,10027) VL,VU,(VEL(I),I=1,IVV)
      WRITE(6,10045) PE,PU,(EHP(I),I=1,IVV)
      WRITE(6,10028) UL,DIAM,EWAKE,FTHRUS,UL,HEAD,UDEN,RHO
      IF(TYPE.LT.2.) TYPE=4
      VU=UEV
      PU=UEP
      UDEN=UED
      UL=UEF
      ESI=EIN
      FSI=EFP
      ANV=EAV
      SNIP=PINS
      SNIR=PINS
      IF(UO.NE.SI) GO TO 143
      VU=USV
      PU=USP
      UDEN=USD
      UL=USL
      SNIP=U09
      SNIP=U08
      ANV=SIV
      DEN2=U02
      DEN3=U03
      FSI=U10
      ESI=U05
143   IF(UI.NE.SI) GO TO 149
C     OPTION FOR SYSTEM INTERNATIONAL INPUT UNITS
      SHP=SHP*PWR
      DIAM=DIAM*ELF
      HEAD=HEAD*ELF
      RHO=RHO*RHOSI
      DO 145 I=1,IVV
      VEL(I)=VEL(I)*VSI
145   EHP(I)=EHP(I)*PWR
      IF(HUB.EQ.0.) GO TO 146
      FWDDIAM=FWDDIAM*ELF
      AFTDIAM=AFTDIAM*ELF
      HUBLEN=HUBLEN*ELF
      FDBORE=FDBORE*ELF
```

```
      ADBORE=ADBORE*ELF
      DISPEFL=DISREFL*ELF
  146  IF(RAKE.GT.0..AND.RAKE.LE..01) GO TO 147
      RAKE=RAKE*ELI
      GO TO 149
  147 DO 148 I=1,JC
  148 RAK(I)=RAK(I)*ELI
  149 CONTINUE
      IF(XPS.GT.0.)  XPS=XPS*JBL(1)/360.
      DIA=DIAM
      IV9=IVV
      DO 10150 I=1,10
10150 TLES(I,2)=INPUT
      TLES(7,2)=TLES(8,2)=LINR
      IF( A5(1).EQ.0.)   TLES(5,2)=LEPBC
      IF(TANB.EQ.0.) TLES(6,2)=CALC
      IF(XPS.LT.0.) TLES(7,2)=NLINR
      IF(RAKE.GT.0..AND.RAKE.LE..01) TLES(8,2)=NLINR
      IF(PDO.LE.0.) TLES(9,2)=PXTNRI
      IF(CD.EQ.0.) TLES(10,2)=CALC
      WRITE(6,10046) IDD
10046 FORMAT(1H  ,4X,I4,*  BASIC DESIGN(S) ASKED FOR* )
      IDEN=DEN
      IF(IDEN.LT.2) IDEN=4
      IF(IDEN.LT.7) DEN=DENS(IDEN)
      IF(IDEN.GE.7.AND.UI.EQ.SI) DEN=DEN*DSI
      IF(RHO.EQ.0.) RHO=1.9905
      IF(RHO.EQ.1.) RHO=1.9384
      PSC=144*.3605*DIAM*DIAM*2
      PTAN=   P(1)/(PI*X3(1))
      AID=DIA
      DUN=DEN
      DAEH=HEAD
      OHR=RHO
      IF(UO.NE.SI) GO TO 150
      AID=AID/ELF
      DUN=DUN/DSI
      DAEH=DAEH/ELF
      OHR=OHR/RHOSI
  150 CONTINUE
      DO 1 I=1,9
      CAV(I)=VEL(I)
  1   CAE(I)=EHP(I)
      IF(SHP) 103,102,103
  103 PVEL=VEL(3)
      PEHP=EHP(3)
  102 CONTINUE
      R(2,1)=CD
      BLAS=JPL(1)
       IF(XPS.GE.0.) GO TO 7
      DO 26 I=1,JC
   26 AZZ(I,38)=AZZ(I,24)
    7  EXXS=2.*BLAS  /PI*SIMPUN(X3,X6,JC)
10008  FORMAT(2H  ,2A2,66H                                       )
     2
       JEA=0
       IF(EXX(1).NE.C.) GO TO 10004
```

```
      EXX(1)=EXXS
      JEA=1
10004 IF(CD.GE.10.)  GO TO 90
      TM=B(2,1)
      CFO=.008
      IF(CD.GT.0.) CFO=1.
      IF(CD.GT.-10. .AND.CD.LT.0.) CFO=-CD
      DO 10007 I=1,JC
      IF(CD.LE.0.) TM=1.+1.25*AZZ(I,25)+125.*AZZ(I,25)**4
      IF(CD.LE.-10.) CFP=B(I,7)
10007 B(I,7)=CFO*TM
   90 DO 15 I=1,JC
   15 AZZ(I,23)=X3(I)
      DO 16 I=3,JC
   16 AZZ(I-1,19)=X3(I)
      AZZ(1,19)=X3(1)
      DO 4 I=1,11
      PXTBI(I)=P(I)
      AZZ(I,36)=AZZ(I,25)
4     AZZ(I,37)=AZZ(I,23)
      DO 10071 IE=1,IZZ
      B(9,2)=JBL(IE)
      XSX=XPS*(360.0/B(9,2))
      AS1=XSX/(1.0-X3(1))
      AS2=XSX-AS1
      DO 10070 KE=1,IEA
      TLES(3,2)=TLES(4,2)=INPUT
      EAPU=EARF
      ERA=ABS( EXXS-EXX(KE) )
      IF(ERA.LT..005.AND.KE.GT.1.AND.JEA.EQ.1) GO TO 10070
      IF(ERA.LE..005)  EARU=EARD
      DO 10069 IRP=1,IRPM
      KI=0
      RPM=XMM(IRP)
      EAR=EXX(KE)
      DO 100 I=1,JC
      B(I,3)=X3(I)
      B(I,4)=X4(I)
  100 B(I,5)=X5(I)
      DO 10051 LE=1,JC
10051 B(LE,6)=(BLAS*EAR*X6(LE))/(B(9,2)*EXXS)
      BDEL=ABS( B(3,6)-X6(3) )
      IF(BDEL.GT..0001) TLES(3,2)=ADDJ
      DO 10052 LE=1,JC
10052 AZZ(LE,25)=AZZ(LE,36)*B(LE,6)
      DO 30 I=1,9
      VEL(I)=CAV(I)
30    EHP(I)=CAE(I)
      B(5,2)=XMM(IRP)/60.0
      IV=1
      IF(SHP.NE. 0.)   GO TO 51
      DO 53 IG=1,IVV
      VEL1(IG)=VEL(IG)
   53 EHP1(IG)=EHP(IG)
      GO TO 21
   51 VEL1(1)=PVEL
      EHP1(1)=PEHP
```

```
   21 DO 5 I=1,11
      AZZ(I,24)=AS1*X3(I)+AS2
       SKZ=ABS(AZZ(1,24))
       IF(SKZ.LT..0001) AZZ(1,24)=0.
       IF(XPS.LT. 0.) AZZ(I,24)=AZZ(I,38)
      AZZ(I,38)=AZZ(I,24)
      AZZ(I,25)=AZZ(I,36)
5     AZZ(I,23)=AZZ(I,37)
       IF(SHP.EQ.0..OR.IV.EQ.1) GO TO 18
      DO 114 J=1,IVV
      B11(J)=VEL(J)
114   B3(J)=EHP(J)
      S1=VEL1(IV)
      CALLDISCOT(S1,S1,B11,B3,B3,-120,JC,0,S2)
      EHP1(IV)=S2
   18 B(6,2)=(325.86*EHP1(IV))/(VEL1(IV)*ETHPUS)
      B(7,2)=1.6878*VEL1(IV)
      NN=0
      BJ=1.0
      JB=BJ
      DDJ=1.0
      JEE=TANBI
      JDD=DDJ
      JD=.666667*FLOAT(JC)
      B(1,1)=3.0
      B(2,1)=CD
      B(3,1)=TANB
      B(4,1)=0.85
      B(6,1)=0.0
      B(7,1)=0.0
      B(8,1)=0.0
      B(9,1)=0.0
      B(1,2)=1.0
      B(2,2)=1.0
      B(8,2)=RHO
      B(5,1)=EWAKE
      B(3,2)=DIA
      B(4,2)=HEAD
      RSL=B(7,2)/(3.14159265*B(5,2)*B(3,2))
       IF(TANB.GT.0.) GO TO 101
      DO 10035 I=1,JC
10035 B(I,8)=RSL/B(I,3)*B(1,4)
  101 AJJ=1.0
       IF( B(1,5).GT.0.) GO TO 10019
       IF( B(5,1).LE.0.) B(5,1)=B(JD,4)
        DO 10018 I=1,JC
10018 B(I,5)= RSL*SQRT(B(5 ,1)*B(I,4))/(B(I,3)*B(4,1))
10019 NN=NN+1
       RAKOP=1
       IF(RAKE.LE..01.AND.RAKE.GT.0.) GO TO 10085
      DO 34 I=1,11
   34  RAK(I)=RAKE*(X3(I)-X3(1))/(X3(11)-X3(1))
10085 VK=B(7,2)/1.6878
      IF(KI.GT.0) GO TO 85
      AJJ=1.0
      WRITE(6,10025)
       PHS=SHP
```

```
      DO 152 I=1,IV9
      IF(UO.EQ.SI) GO TO 151
      DMV(I)=VEL(I)
      DME(I)=EHP(I)
      GO TO 152
  151 DMV(I)=VEL(I)/VSI
      DME(I)=EHP(I)/PWR
  152 CONTINUE
      WRITE(6,10008) UI,UO
      IF(SHP.NE.0.) WRITE(6,10021) PU,   PHS  ,DEN1,DEN2,DEN3,DUN
      IF(SHP.EQ.0.) WRITE(6,10020) SHPT1,SHPT2,DEN1,DEN2,DEN3,DUN
      WRITE(6,10027) VL,VU,(DMV(I),I=1,IV9)
      WRITE(6,10045) PE,PU,(DME(I),I=1,IV9)
      WRITE(6,10028) UL, AID,EWAKE,ETHRUS,UL,DAEH,UDEN,DHR
10028 FORMAT(/2X,*D*,A4,*=*,F8.4,* ,1-WTT=*,F5.4,* ,1-THD=*,F5.4,* ,H*,
     2  A4,*=*,F8.4,* ,RHO*,A10,*=*,1X,F9.4,/)
      WRITE(6,10030) (JBL(I),I=1,IZ7)
      WRITE(6,10031) EXA, (EXX(I),I=1,IEA)
      WRITE(6,10032) URPM,(XMM(I),I=1,IRPM)
10025 FORMAT(1H1)
10020  FORMAT(/,2A7,2A10,A8,F10.4,/)
10021  FORMAT(/,* PS(*,A3,,*=*,1PE12.4,2A10,A8,0PF10.4,/)
10030  FORMAT(2X,*Z*,9X,9I3)
10031  FORMAT(2X,A5,5X,1P9E12.4)
10032  FORMAT(2X,*N*,A9,1P9E12.4)
10027  FORMAT(2X,A2,A6,2X,1P9E12.4)
10045  FORMAT(2X,2A3,4X,1P9E12.4)
       WRITE(6,10100) (TLES(I,1),I=1,10)
       WRITE(6,10101) (TLES(I,2),I=1,10)
10100  FORMAT(/,1X, 10(3X,A10))
10101  FORMAT(1X, 10(3X,A10),/)
       DO 10111 I=1,JC
       IF(FOO.LE.0.) P(I)=0
       SRK=RAK(I)/DIA/12.
10111  WRITE(6,10102) X3(I),X4(I),B(I,6),AZZ(I,25),B(I,5),B(I,8),
     2 AZZ(I,24),SRK,P(I),B(I,7)
10102  FORMAT(1P10E13.4)
   85 DO 10090 I=1,JC
      AZZ(I,25)=AZZ(I,25)*B(I,6)
10090 B(I,30)=B(I,5)*AJJ
       IF(JEE.LE.0) GO TO 47
      DO 209 IOC=1,3
      DO 201 I=1,JC
201   B(I,30)=B(I,30)*AJJ
      B14(41)=.975
      B14(42)=1.000
      B14(43)=1.025
      DO 215 IJ=41,43
      IJT=IJ+4
      IJP=IJ+8
      DO 216 I=1,JC
216   B(I,5)=B(I,30)*B14(IJ)
      CALL SUB
      B14(IJT)=PP7
      B14(IJP)=PP8
  215 CONTINUE
       JK=44
```

```
      TTT=B(6,2)/((B(8,2)*B(3,2)**2*3.1415927*B(7,2)**2)/8.)
       IF( B(1,2).GT.0. )  GO TO 10
       JK=48
       TTT=TTT*550./B(7,2)
10    DO 11 I=1,3
       CC(I,1)=B14(JK+I)
      DO 11 J=1,3
      K=3*(J-1)+I
       B15(40+K)=B14(40+J)**(I-1)
11    C(J,I)=B15(K+40)
      CALL SIMEQ(3,C,CC)
  208 AJJ=(-CC(2,1)+SQRT(CC(2,1)**2-4.*CC(3,1)*(CC(1,1)-TTT)))/(2.*CC(3,
     11))
48    DO 49 I=1,JC
   49 B(I,5)=B(I,30)*AJJ
   47 JEC=0
      CALL SUB
      PP11=B15(181)*ETHRUS
      PP12=EHP1(IV)/PP11
      THP=B(6,2)
      ATHR=B(8,2)/8.0*3.14159*(B(3,2)**2)*(B(7,2)**2)*PP7
      ASHP(IV)=PP12
       IF(SHP) 55,10050,55
   55 CONTINUE
      KI=KI+1
      IF(KI.GE.6) GO TO 10050
      IF(ABS((SHP-ASHP(IV))/ASHP(IV))-.0005) 10050,10050,20
   20  NI=.33
       IF(IV.EQ.1) GO TO 820
       NI=ALOG( VEL1(IV-1)/VEL1(IV) )/ALOG( ASHP(IV-1)/ASHP(IV) )
  820  VEL1(IV+1)=VEL1(IV)*( (SHP/ASHP(IV))**NI )
       AVL=VEL1(IV+1)
       IF(AVL.GT.CAV(5).OR.AVL.LT.CAV(1)) WRITE(6,922) AVL
  922 FORMAT(////10X,*ESTIMATED VELOCITY VALUE IN ITERATION FOR DESIRED
     1SHP IS NOT WITHIN RANGE OF INPUT VELOCITY VALUES...*/15X,*...PROGR
     2AM CANNOT EXTRAPOLATE FOR CORRESPONDING EHP.   ESTIMATED VELOCITY
     3VALUE = *1PE10.4)
       IV=IV+1
       GO TO 21
10050 DO 10049 IX=1,IV
       EHP(IX)=EHP1(IX)
10049 VEL(IX)=VEL1(IX)
      DO 40050 I=1,JC
      AZZ(I,26)=B(I,14)
      AZZ(I,27)=B(I,5)
       BI=AZZ(I,27)
       IF(POO.GT.0.) BI= P(I)/PI/X3(I)
        CII=AZZ(I,24) *B(I,3)*SQRT(1.+BI*BI)*PI/180.
      AZZ(I,28)=CII-B(I,6)
      AZZ(I,29)=CII+B(I,6)
      AZZ(I,30)=B(I,6)
      AZZ(I,31)=B(I,4)
      AZZ(I,32)=B(I,12)
      AZZ(I,33)=B(I,13)
      AZZ(I,34)=AZZ(I,25)*2.0
40050 AX(I)=AZZ(I,34)
      IF(AZZ(11,25).NE.0.) GO TO 5555
```

```
      SLP=(AZZ(9,34)-AZZ(6,34))/(AZZ(9,23)-AZZ(6,23))
      YINT=AZZ(9,34)-(AZZ(9,23)*SLP)
      AZZ(10,34)=(SLP*AZZ(10,23))+YINT
      AZZ(11,34)=(SLP*AZZ(11,23))+YINT
 5555 DO 40052 K=26,34
      DO 40051 J=1,11
      B11(J)=B(J,3)
40051 B3(J)=AZZ(J,K)
      DO 40052 I=1,11
      S1=AZZ(I,23)
      CALL DISCOT(S1,S1,B11,B3,B3,-120,JC,0,S2)
40052 AZZ(I,K)=S2
      DO 5050 I=1,JC
      AZZ(I,2)=B(I,2)
      B(I,20)=B(I,15)
      B(I,21)=B(I,5)
       BI=B(I,21)
       IF(PDO.GT.0.) BI= P(I)/PI/X3(I)
      B(I,22)=B(I,38)
      B(I,23)=B(I,5)
      B(I,24)=AZZ(I,24)
      B(I,25)=AZZ(I,25)
      TX(I)=B(I,25)*DIA*12.0
 5050  B(I,24)=B(I,24)*B(I,3)*SQRT(1.+BI*BI)*PI/180.
      BT(11)=B(11,5)
C       OBTAIN DATA AT PROPER RADIAL STATIONS FOR STRESS PROGRAM
       DO 50080 I=1,10
       D=AZZ(I,19)
       DO 50030 K=20,24
50030  CALL DISCOT(D,D,B(1,3),B(1,K),B(1,K),-120,JC,0,AZZ(I,K))
       CALL DISCOT(D,D,B(1,3),P,P,-120,JC,0,CX(I))
       CALL DISCOT(D,D,B(1,3),B(I,18),B(I,18),-120,JC,0,AZZ(I,18))
50080  CONTINUE
       DO 50090 I=1,10
50090  P(I)=CX(I)

       CALL STRESS(AZZ,AREA,XBAR,YBAR,AYEXO,AYEYO,EMXO,EMYO,EMTR,EMOR,STR
      1MAX,RAK,RAKOP)
C          THE FOLLOWING STATEMENTS HAVE BEEN ADDED IN ORDER TO SEND THE R
C          VALUES TO SUBROUTINE WEIGHT.  CHORD,THICKNESS, AND CAMBER ARE I
C          PITCH AND SKEWR ARE IN RADIANS.
       VS=VK*1.6878
       DO 999 I=1,JC
        IF(PDO.GT.0.) P(I)=PXTBI(I)
       X(I)=B(I,3)
        IF( X(I).GT. .65  .AND.  X(I).LT. .75)  SIGMA=B(I,19)
       CHORD(I)=B(I,6)*DIAM
       THICKNS(I)=AZZ(I,34)*DIAM/2.
       PITCH(I)=ATAN(B(I,5))
       BBJ(I)=ATAN(B(I,8))
       FX(I)=0.0
        IF(CL1(I).EQ. 0.) GO TO 29
       FX(I)=1.0/(1.0+(6.2832*TAN(PITCH(I)-BBJ(I))/CL1(I)))
    29 CONTINUE
        BI=P(I)/PI/X3(I)
        IF(PDO.GT.0.) PITCH(I)=ATAN(BI)
       SKEWR(I)=AZZ(I,38)/57.2958
```

```
      AZZ(I,34)=AX(I)
      AV   =(B(I,4)+B(I,12))**2
      BV   =(B(I,4)/B(I,8)-B(I,13))**2
      VSUBRSQ(I)=VS**2*(AV   +BV   )
      VSUBR(I)=SQRT(VSUBRSQ(I))
  999 CAMBER(I)=.0679*B(I,18)*DIAM
      RPS=RPM/60.
      DO 996 I=1,JC
      PXTBI(I)=PI*B(I,3)*B(I,5)
      PXTB(I)=PI*B(I,3)*B(I,8)
  996 CONTINUE
      EA1=(EAR*3.14159*DIA**2)/4.0
      AL=3.14159*0.7*B(7,5)
      AP=EA1*(1.067-0.229*AL)
      VA=VS*B(7,4)
      VR=SQRT(VA**2+(0.7*3.14159*RPS*DIA)**2)
      TC=2.0*B(6,2)/(RHO*AP*VR**2)
      SIGMA7=(64.4*HEAD)/VR**2
      WRITE(6,10042)
10042 FORMAT(1H )
       UVR=VU
       IF(UO.NE.SI) UVR=UVE
       WRITE(6,78) UVR
      DO 79 I=1,11
       VRSI=VSUBR(I)
       IF(UO.EQ.SI) VRSI=VRSI*.3048
   79 WRITE(6,80)    B(I,3),B(I,5),B(I,8),B(I,14),B(I,13),B(I,12),B(I,15)
     1 ,B(I,17),VRSI,B(I,19)
      WRITE(6,10042)
      WRITE(6,77)    PP1,PP3,PP4,PP2,PP5
      WRITE(6,81)    PP6,PP8,PP9,PP7,PP10
      WRITE(6,10042)
       ULO=ULE
       IF(UO.EQ.SI) ULO=ULS
       WRITE(6,76) ULO
      DO 75 I=1,11
       SLI=.5*RHO*VSUBRSQ(I)*CL1(I)* B(I,6)*DIA
       IF(UO.EQ.SI) SLI=SLI*14.5939
   75  WRITE(6,20046) B(I,3),CCONE(I),CCTWO(I),CCTHR(I),COEOP(I),FX(I),
     2 SLI,AZZ(I,38),AZZ(I,28),AZZ(I,29),AZZ(I,34)
      WRITE(6,10042)
       ANV=EAV
       P12=PP12
       RTH=THR
       UB=UFI
       UTO=UFE
       BTHR=ATHR
       UST=UPIN2
       VLS=B(7,2)
       V2=UVE
       U02=ULE2
       U04=ULE4
       UMO=UIL
       USTR=ULPIN2
       IF(UO.NE.SI) GO TO 100
       U02=ULS2
       U04=ULS4
```

```
      UMO=UNM
      USTP=UPA
      UST=UPA
      UB=USL
      UTO=UFS
      V2=USV
      VLS=VLS*.3048
      P12=P12/PWR
      RTH=RTH/UWT
      BTHR=BTHR/UWT
  160 WRITE(6,10044) PP11,PU,P12,ETHRUS,EWAKF,VL,UEV,VK,UTO,RTH,JBL(IE)
     2 ,RPM,EARU,EXA,EAR,VL,V2,VLS,UTO,BTHR
      IF(UO.EQ.SI) WRITE(6,10010) UO2,U8,UB,UO4,UO4,UMO,UMO,UMO,UMO,UST
      IF(UO.NE.SI) WRITE(6,20009)
      IF(UO.NE.SI) WRITE(6,20010) UO2,U8,UB,UO4,UO4,UMO,UMO,UMO,UMO,UST
   77 FORMAT(4X,*CPTI=*,1PE10.4,4X,*CPSI=*,1PE10.4,4X,*ETAI=*,1PE10.4,
     2 4X,*CTSI=*,1PE10.4,4X,*CTSI/CPSI=*,1PE10.4)
   78 FORMAT(6X,* X*,8X,*TANBI*,7X,*TAN B*,9X,*G*,9X,*UT/2V*,7X,
     2 *UA/2V*,7X,*DCTSI*,7X,*DCPSI*,5X,*VR(*,A7,5X,*CAVV*)
   80 FORMAT(1P10E12.4)
   81 FORMAT(5X,*CPT=*,1PE10.4, 5X,*CPS=*,1PE10.4,5X,*ETA=*,1PE10.4,5X,
     2 *CTS=*,1PE10.4,6X,*CTS/CPS=*,1PE10.4)
   75 FORMAT(5X,* X*,8X,*CL *,6X,*ALI(DEG)*5X,*FM/C*,7X,*CD/CL*,7X,
     2 *F(X)*,4X,*LI*,A8,2X,*TETS(DEG)*2X,*(C/PD)LE*,4X,*(C/PD)TE*,6X,
     3 *T/PD* )
20046 FORMAT(1PE10.3,1P10E11.3)
10044 FORMAT(1X,*ETAD=*,1PE10.4,4X,*PS(*,A4,*=*,1PE10.4,3X,*1-THD=*,
     2 ,1PE10.4 ,
     2 3X,*1-WTT=*,1PE10.4,3X,A2,A8,*=*,1PE10.4,7X,*DESIGN TH*,A5,*=*,
     3          1PE10.4,/,4X,*Z=*,I2, 9X,*N(REV/MIN)=*,1PE10.4,14X,
     4 A8,A5,*=*,1PE10.4,3X,A2,A7, * =*  ,1PE10.4,3X,*CALCULATED TH*,
     5 A5,*=*,1PE10.4)
      DO 74 I=1,7
      SX(I)=AZZ(I,19)
      APR=AREA(I)
      XPR=XBAR(I)
      YPR=YBAR(I)
      XOI=AYEXO(I)
      YOI=AYEYO(I)
      XOM=EMXO(I)
      YOM=EMYO(I)
      TBM=EMTB(I)
      OBM=EMOB(I)
      STRM=STRMAX(I)
      IF(UO.NE.SI) GO TO 74
      APR=APR*EL2
      XPR=XPR/ELI
      YPR=YPR/ELI
      XOI=XOI*EL2*EL2
      YOI=YOI*EL2*EL2
      XOM=XOM/SIM
      YOM=YOM/SIM
      TBM=TBM/SIM
      OBM=OBM/SIM
      STRM=STRM*6894.757
   74 WRITE(6,20047) SX(I),APR,XPR,YPR,XOI,YOI,XOM,YOM,TBM,OBM,STRM
20047 FORMAT(1PE10.3,1P5E11.3,1P5E12.3)
```

```
20009  FORMAT(1H1,4X,*X*,9X,*AREA*,7X,*XBAR*,7X,*YBAR*,7X,*IXO*,8X,*IYO*
     2 ,9X,*MXO*,9X,*MYO*,9X,*MTB*,9X,*MOB*,6X,*MAXSTRESS* )
20010  FORMAT(15X,A5,6X,A4,7X,A4,6X,A5,6X,A5,6X,A3,4X,A8,4X,A8,4X,A8,3X,
     2A9)
10010  FORMAT(1H1,4X,*X*,7X,*AREA*,A5,4X,*XBAR*,A4,2X,*YBAR*,A4,2X,*IXO*
     2  ,A5,3X,*IYO*,A5,4X,*MXO*,A8,1X,*MYO*,A8,1X,*MTB*,A8,1X,*MOB*,A8,
     3      *MAXSTRESS*,A9)
      WRITE(6,10042)
      WRITE(6,10042)
      WRITE(6,10011)
      DO 73 I=1,11
       SRK=RAK(I)*DIA/12.
       WRITE(6,10012) B(I,3),SRK,PXTBI(I),PXTB(I)
   73  IF(PDO.GT.0.) PXTBI(I)=P(I)
10011  FORMAT(5X,*X*,8X,*RAKG/D*,1X, 23H  PI XTANBI    PI XTANB    )
10012 FORMAT(1PE10.3,1P3E11.3)
      CALL WEIGHT(JC,SIGMA7,HUB,PMHC,WEIGHTB,WEIGHTH,RAK)
       SBI=SIN( PITCH(1) )
 3214 HUBSPAC=2.0*PI*X(1)*DIA*6.0/B(9,2)
       TBI=AX(1)*DIAM*6./SBI
       BLASPAC=HUBSPAC-TBI
       FILSPAC=BLASPAC-.9*TBI
      WRITE(6,998) TC,SIGMA7
       BLS=BLASPAC/DIA/12.
       FILS=FILSPAC/DIA/12.
       UF=EFT
       UMI=PMI
       IF(UO.NE.SI) GO TO 158
       UF=U04
       UMI=U07
  158  CONTINUE
       WRITE(6,994)     BLS,   FILS
  998 FORMAT(/20X,*BURRILL THRUST COEFF     TC=*,F10.4//20X,*BURRILL CAVI
     1TATION COEFF     SIGMA(0.7)=*,E10.4)
  994  FORMAT(/20X,*CLEARANCE AT HUB BETWEEN BLADES/D=*,1PE12.4,//,
     2 20X,*CLEARANCE AT HUB BETWEEN FILLETS/D=*,1PE12.4)
      DO 122 I=1,11
       ARPMI(I)=B(I,6)*AZZ(I,25)*PSC
  122 PMDX(I)=ARPMI(I)*X(I)**2
      PMOFIB=B(9,2)*DEN/1728.*(DIAM*6.0)**3*SIMPUN(X,PMDX,JC)
      TPMIN=PMOFIB+PMHC
      RADOGB=SQRT(PMOFIB/WEIGHTB)/12.
      RADOGH=SQRT(PMHC/WEIGHTH)/12.
      RADOGT=SQRT(TPMIN/(WEIGHTB+WEIGHTH))/12.
       PMS=PMOFIB
       TPS=TPMIN
       GRB=RADOGB/DIA
       GRH=RADOGH/DIA
       GRT=RADOGT/DIA
       IF(UO.NE.SI) GO TO 171
       PMS=PMS*.00029264
       TPS=TPS*.00029264
  171  WRITE(6,995) UMI,PMS,UMI,TPS,GR1,GR2,   GRB,GR1,GR2,    GRH,
     2 GR1,GR2,    GRT
  995  FORMAT(1H1,19X,*MASS POLAR MOMENT OF INERTIA OF BLADES *,A10,
     2 E13.6,//,20X,*TOTAL MASS POLAR MOMENT OF INERTIA *,A10,E13.6,//,
     3 20X,2A9,* OF BLADE/D=*      ,F9.4,//20X,2A9,* OF HUB/D=*     ,F9.4,
```

```
     4 //,20X,*TOTAL *,2A9,     */D=*,F9.4)
C    THIS SECTION CALCULATES THE ABS COEFFICIENTS
      IF(TYPE.EQ.0.) GO TO 570
      RAD=0.25
      IF(B(1,3).GE.0.25) RAD=B(1,3)+.05
      IF(B(2,3).EQ.0.25) GO TO 590
      DO 510 J=1,11
      B11(J)=B(J,3)
  510 B3(J)=PXTBI(J)
      S1=.25
      IF(B(1,3).GE.0.25) S1=RAD
      CALL DISCOT(S1,S1,B11,B3,B3,-120,JC,0,S2)
      PTWOFIV=S2
      DO 513 J=1,11
      B11(J)=B(J,3)
  513 B3(J)=B(J,6)*DIAM*12.0
      S1=.25
      IF(B(1,3).GE.0.25) S1=RAD
      CALL DISCOT(S1,S1,B11,B3,B3,-120,JC,0,S2)
      DUBLU=S2
      DO 516 J=1,11
      B11(J)=B(J,3)
  516 B3(J)=ARPMI(J)
      S1=.25
      IF(B(1,3).GE.0.25) S1=RAD
      CALL DISCOT(S1,S1,B11,B3,B3,-120,JC,0,S2)
      ATWOFIV=S2
      DO 569 J=1,11
      B11(J)=B(J,3)
  569 B3(J)=THICKNS(J)*12.0
      S1=.25
      IF(B(1,3).GE.0.25) S1=RAD
      CALL DISCOT(S1,S1,B11,B3,B3,-120,JC,0,S2)
      TMAX=S2
      UF=0.5*TMAX
      GO TO 592
  590 PTWOFIV=PXTBI(2)
      DUBLU=B(2,6)*DIAM*12.0
      ATWOFIV=ARPMI(2)
      TMAX=THICKNS(2)*12.0
      UF=0.5*TMAX
  592 CONTINUE
      IF(B(7,3).EQ.0.7) GO TO 596
      DO 595 J=1,11
      B11(J)=B(J,3)
  595 B3(J)=PXTBI(J)
      S1=.7
      CALL DISCOT(S1,S1,B11,B3,B3,-120,JC,0,S2)
      PSEVEN=S2
      GO TO 597
  596 PSEVEN=PXTBI(7)
  597 CONTINUE
      RAKE2=RAK(11)+DIAM*AZZ(11,38)*P(11)/30.
      DO 519 J=1,7
      B11(J)=SX(J)
  519 B3(J)=AYEXO(J)
      S1=.25
```

```
      IF(SX(1).GE.0.25) S1=SX(1)+0.05
      CALL DISCOT(S1,S1,B11,B3,B3,-120,7,0,S2)
      AYO=S2
       F=INT(TYPE/2)*68.+INT(TYPE/3)*5.-INT(TYPE/4)*56.-INT(TYPE/6)*127.
       WL=INT(TYPE/2)*.3-INT(TYPE/3)*.01-INT(TYPE/4)*.32-INT(TYPE/6)*.30
      CS=ATWOFIV/(DUBLU*TMAX)
       CN=AYO/(UF*DUBLU*TMAX**2)
      AA=1.0+6.0/PSEVEN+4.3*PTWOFIV
      BA=4300.*WL*EAR      /B(9,2)*(RPM/100.)**2*(DIAM/20.)**3
      CA=(1.0+1.5*PTWOFIV)*(DUBLU*F-BA)
       ANEW=13.*SQRT(AA*PP12/(CA*RPM*B(9,2)) )
       BNEW=CS*BA/4./CA
       BTHICK1= ANEW/SQRT(CN)+BNEW/CN*RAK(11)
       BTHICK2=ANEW/SQRT(CN)+BNEW/CN*RAKE2
      WRITE(6,530) RAD
  530 FORMAT(////29X,*ABS COEFFICIENTS (CALCULATED AT THE*,F4.2,* RADIUS
     1)*)
       TABS(5)=TBS
       TABS(6)=UBS
       IF(PDO.GT.0.) TABS(5)=VBS
       IF(PDO.GT.0.) TABS(6)=XBS
       BS1=BTHICK1/DIA/12.
       BS2=BTHICK2/DIA/12.
       ATF=ATWOFIV
       IF(UO.NE.SI) GO TO 172
       ATF=ATF*.00064516
  172  WRITE(6,541) TABS,BS1,BS2,AA,BA,CA,CS,CN,SNIR,ATF
  541  FORMAT(//20X,6A10,
     2      /40X*USING ABS RAKE = CONVENTIONAL RAKE,  T/D= *E10.4/40X*USI
     BNG ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= *E10.4
     2                         //20X*VALUES USED IN DETERMINING THICKNESS-
     3      A= *E12.6/62X*B= *E12.6/62X*C= *E12.6//20X*SECTION AREA COEFF
     4ICIENT      CS= *E10.4//20X*SECTION MODULUS COEFFICIENT     CN= *E1
     50.4//20X*AREA OF EXPANDED CYLINDRICAL SECTION IN SQ.*,A6,5X,*AS=*,
     6 E10.4)
       CN=.1
       BTHICK1= ANEW/SQRT(CN)+BNEW/CN*RAK(11)
       BTHICK2=ANEW/SQRT(CN)+BNEW/CN*RAKE2
       BS2=BTHICK2/DIA/12.
       BS1=BTHICK1/DIA/12.
       WRITE(6,543) TABS,BS1,BS2
  543  FORMAT(//////,20X,*FOR CN=.1*,/,20X,6A10,
     2      /40X*USING ABS RAKE = CONVENTIONAL RAKE,  T/D= *E10.4/40X*USI
     BNG ABS RAKE = CONVENTIONAL + SKEW-INDUCED RAKE,  T/D= *E10.4)
  570 CONTINUE
      BLADEL=B(11,3)-B(1,3)
      DELTA=BLADEL/8.
      DELTA1=DELTA/2.
      DO 132 I=1,11
      XR(I)=B(I,3)
      TANBETI(I)=B(I,5)
      G(I)=B(I,14)
      XSL(I)=AZZ(I,28)
      XST(I)=AZZ(I,29)
      WAKE(I)=B(I,4)
      UVELA(I)=B(I,12)
      THICKR(I)=AZZ(I,34)
```

```
  132 CONTINUE
      XR(12)=XR(1)+DELTA1
      XR(13)=XR(1)+DELTA
      DO 130 I=14,19
      XR(I)=XR(I-1)+DELTA
  130 CONTINUE
      XR(20)=XR(19)+DELTA1
      DO 131 I=12,20
      CALL DISCOT(XR(I),XR(I),XR,TANBETI,XR,-044,11,0,TANBETI(I))
      CALL DISCOT(XR(I),XR(I),XR,G,XR,-044,11,0,G(I))
      CALL DISCOT(XR(I),XR(I),XR,XSL,XR,-044,11,0,XSL(I))
      CALL DISCOT(XR(I),XR(I),XR,XST,XR,-044,11,0,XST(I))
      CALL DISCOT(XR(I),XR(I),XR,WAKE,XR,-044,11,0,WAKE(I))
      CALL DISCOT(XR(I),XR(I),XR,UVELA,XR,-044,11,0,UVELA(I))
      CALL DISCOT(XR(I),XR(I),XR,THICKR,XR,-044,11,0,THICKR(I))
      XSL(I)=XSL(I)*DIA*6.
      XST(I)=XST(I)*DIA*6.
      THICKR(I)=THICKR(I)*DIA*6.
  131 CONTINUE
      WRITE(6,133)
  133 FORMAT(1H1,////,10X,*RADIAL PROPELLER DATA FOR INPUT INTO DESIGN P
     1ROGRAMS(8 RADIAL STRIPS ASSUMED)*,///)
       WRITE(6,134) SNIP,SNIP,SNIP
  134  FORMAT(10X,*XR*,5X,*TAN BETA I*,8X,*G*,7X,*XSL(*,A7,5X,*XST(*,A7,
     2 5X,*1-WX*,8X,*UA/2VS*,5X,*THICKNESS(*,A7,/)
       DO 174 I=12,20
       SSL=XSL(I)
       SST=XST(I)
       STHR=THICKR(I)
       IF(UO.NE.SI) GO TO 174
       SSL=SSL/ELI
       SST=SST/ELI
       STHR=STHR/ELI
  174  WRITE(6,135) XR(I),TANBETI(I),G(I),SSL,SST,WAKE(I),UVELA(I),STHR
  135 FORMAT(4X,F10.5,3X,F10.5,3X,E12.4,3X,F10.5,4X,F10.5,1X,F10.5,4X,E1
     12.4,5X,F10.5)
      XSL(11)=XSL(11)*DIA*6.
      XST(11)=XST(11)*DIA*6.
       SSL=XSL(11)
       SST=XST(11)
       IF(UO.NE.SI) GO TO 175
       SSL=SSL/ELI
       SST=SST/ELI
  175  WRITE(6,136) XR(11),SSL,SST
  136 FORMAT(4X,F10.5,31X,F10.5,4X,F10.5)
       IF(SHP.NE.0.) GO TO 10069
      IV=IV+1
       IF(IV.LE.IVV) GO TO 21
10069  CONTINUE
10070  CONTINUE
10071  CONTINUE
10072 CONTINUE
      STOP
      END
```

```
      SUBROUTINE SUB
      DIMENSION CHORD(11),THICKNS(11),CAMBER(11),PITCH(11),SKEWR(11)
     1 ,XI(11)
      DIMENSION P(13),BT(11)
      COMMON/CWEIGHT/XI,CHORD,THICKNS,CAMBER,PITCH,SKEWR,DIAM,ZZ,DEN
     1,RAKE,PI,PP7,PP8,PP9,PP11,EWAKE,VS,RPS,SIGMA,EAR,BT,P,PDO
     2  ,FWDDIAM,AFTDIAM,HUBLEN,FORBORE,ADBORE,DISREF!
      DIMENSION B(38,38),        B2(181),B3(181)
     1 ,B11(181),B14(181)
     2    ,B15(181),AZ(11,11),BH(11,11),C(12,12),CC(12,12)
      COMMON B,   B2,B3,                    B11         ,B14,B15,AZ,BH,
     1C,CC,      ID,JB,JC,JD,JDD,JEE,CL1(11)
      COMMON CCONE(11),CCTWO(11),CCTHR(11),CCFOR(11)
      COMMON PP1,PP2,PP3,PP4,PP5,PP6,PP10
      COMMON SN(73),CS(73)
10252 DO 10025 N=1,JC
      DO 20021 I=1,JC
      AAG=1./B(I,5)
      AAH=B(N,3)/B(I,3)*AAG
      AAQ=B(I,5)
      IF(AAH-AAG)10019,10018,10019
10018 B2(I)=1./SQRT(1.+AAQ*AAQ)
      B3(I)=AAQ*B2(I)
      GO TO 20021
10019 S=1.+AAH**2
      T=SQRT(S)
      V=1.+AAG**2
      W=SQRT(V)
      AE=T-W
      U=EXP(AE)
      R=(((T-1.)/AAH*(AAG/(W-1.)))*U)**B(9,2)
      AC=1.5
      AD=.25
      X=(1./(2.*B(9,2)*AAG))*((V/S)**AD)
      Y=((9.*AAG**2)+2.)/(V**AC)+((3.*AAH **2-2.)/(S**AC))
      Z=1./(24.*B(9,2))*Y
      IF(AAH-AAG)10021,10021,10020
10020 AF=1.+1./(R-1.)
      AA=X*(1./(R-1.)-Z*ALOG(AF))
      B2(I)  =2.*B(9,2)**2*AAG*AAH*(1.-AAG/AAH)*AA
      B3(I)  =B(9,2)*(1.-AAG/AAH)*(1.+2.*B(9,2)*AAG *AA)
      GO TO 20021
10021 AG=1.+1./(1./R-1.)
      AB=-X*(1./(1./R-1.)+Z*ALOG(AG))
      B2(I)  =B(9,2)*AAG*(1.-AAH/AAG)*(1.-2.*B(9,2)*AAG*AB)
      B3(I)  =2.*B(9,2)**2*AAG*(1.-AAG/AAH)*AB
20021 CONTINUE
20024 FORMAT(9F12.4)
      DO 2 I=1,JC
    2 B11(I)=B(I,3)
      DO 3 I=1,37
      S1    =.5*(1.+B(1,3))-.5*(1.-B(1,3))*CS(I)
      CALL DISCOT(S1,S1,B11,B3 ,B3 ,-120,JC,0,S3)
3     B15(I)=S3
      DO 5 I=1,37
      S1    =.5*(1.+B(1,3))-.5*(1.-B(1,3))*CS(I)
      CALL DISCOT(S1,S1,B11,B2 ,B2 ,-120,JC,0,S2)
```

```
5      B14(I)=S2
       DO 4 I=1,37
       B2(I)=B14(I)
4      B3(I)=B15(I)
       DO 10022 L=1,35
       N1=37+L
       N2=37-L
       B2(N1)=B2(N2)
10022  B3(N1)=B3(N2)
       C2=2./72.
       NP=72
       NH=36
       XNP=NP
       S=0.0
       SL=0.0
       DO 20 I=1,NP
       S=S+B2(I)
   20  SL=SL+B3(I)
        B(1,9)=S/XNP
        B(1,10)=SL/XNP
       DO 40 I=1,NH
       S=0.0
       SL=0.0
       DO 30 J=1,NP
        K=(J-1)*I
        K=MOD(K,72)+1
        S=S+B2(J)*CS(K)
   30   SL=SL+B3(J)*CS(K)
        L=I+1
        B(L,9)=S*C2
   40   B(L,10)=SL*C2
       CPHI=((1.+B(1,3))-2.*B(N,3))/(1.-B(1,3))
        IF(CPHI.LT.-1.) CPHI=-1.
        IF(CPHI.GT.1.) CPHI=1.
       B(N,11)=ACOS(CPHI)
       B(1,11)=.0
       B(JC,11)=3.1415927
       CON3=3.1415927
       DO 10025 I=1,JC
       SMP=SIN(FLOAT(I)*B(N,11))
       CMP=COS(FLOAT(I)*B(N,11))
       IF(N-1)10027,10026,10027
10027  IF(N-JC)10028,10029,10028
10026  AZN=.0
       BZN=.0
       N2=I+1
       DO 20026 K=1,N2
       IF(K-JC)10070,10070,20026
10070  AZN=AZN+CON3*FLOAT(I)*B(K,9)
       BZN=BZN+CON3*FLOAT(I)*B(K,10)
20026  CONTINUE
       AZL=.0
       BZL=.0
       IF(N2-JC)10060,10030,10030
10060  N1=N2+1
       DO 20036 M=N1,JC
       L=M-1
```

```
      AZL=AZL+FLOAT(L)*B(M,9)*CON3
20036 BZL=BZL+FLOAT(L)*B(M,10)*CON3
      GO TO 10030
10029 AZN=.0
      BZN=.0
      N2=I+1
      DO 20029 K=1,N2
      CKP=COS(FLOAT(K-1)*B(N,11))
      IF(K-JC)10071,10071,20029
10071 AZN=AZN-CON3*CMP*FLOAT(I)*B(K,9)*CKP
      BZN=BZN-CON3*CMP*FLOAT(I)*B(K,10)*CKP
20029 CONTINUE
      AZL=.0
      BZL=.0
      IF(N2-JC)10061,10030,10030
10061 N1=N2+1
      DO 20039 M=N1,JC
      L=M-1
      CKP=COS(FLOAT(L)*B(N,11))
      AZL=AZL-CON3*CMP*FLOAT(L)*B(M,9)*CKP
20039 BZL=BZL-CON3*CMP*FLOAT(L)*B(M,10)*CKP
      GO TO 10030
10028 AZN=.0
      BZN=.0
      CON1=3.1415927/SIN(B(N,11))
      N2=I+1
      DO 20028 K=1,N2
      CKP=COS(FLOAT(K-1)*B(N,11))
      IF(K-JC)10072,10072,20028
10072 AZN=AZN+CON1*SMP*B(K,9)*CKP
      BZN=BZN+CON1*SMP*B(K,10)*CKP
20028  CONTINUE
      AZL=.0
      BZL=.0
      IF(N2-JC)10062,10030,10030
10062 N1=N2+1
      DO 20038 M=N1,JC
      L=M-1
      SKP=SIN(FLOAT(L)*B(N,11))
      AZL=AZL+CON1*CMP*B(M,9)*SKP
20038 BZL=BZL+CON1*CMP*B(M,10)*SKP
10030 AZ(I,N)=AZN+AZL
      BH(I,N)=BZN+BZL
10025 CONTINUE
      DO 10031 I=1,JC
      DO 10031 J=1,JC
      CC(I,1)=(1.-B(1,3))*(B(I,5)/B(I,8)-1.)*B(I,4)
10031 C(I,J)=FLOAT(J)*(AZ(J,I)+B(I,5)*BH(J,I))
      CALL SIMEQ(JC,C,CC)
      DO 10035 I=1,JC
      B(I,12)=.0
      B(I,13)=.0
      B(I,14)=.0
      DO 10035 J=1,JC
      B(I,12)=B(I,12)+FLOAT(J)*CC(J,1)*AZ(J,I)/B(I,4)*(1./(1.-B(1,3)))
      B(I,13)=B(I,13)+FLOAT(J)*CC(J,1)*BH(J,I)/B(I,4)*(1./(1.-B(1,3)))
10035 B(I,14)=CC(J,1)*SIN(FLOAT(J)*B(I,11))/B(I,4)+B(I,14)
```

```
      B(JC,14)=.0
20001 DO 10038 I=1,JC
      B(I,15)=(B(I,14)*B(I,4)*(B(I,4)/B(I,8)-B(I,13)*B(I,4)))*4.*B(9,
     12)
      B(I,16)=B(I,15)*B(I,4)
      B(I,17)=(B(I,4)/B(I,8)*B(I,14)*B(I,4)*(B(I,4)+B(I,12)*B(I,4)))*4.
     1*B(9,2)
      BTT=ATAN(B(I,8))
      BTI=ATAN(B(I,5))
      B(I,18)=2.*3.1415927*B(I,14)*COS(BTI)/(1./B(I,8)-B(I,13))
      B(I,19)=64.31*(B(4,2)-B(I,3)*B(3,2)   /2.)*(SIN(BTT)/(B(I,4)*B(7,2)
     1*COS(BTI-BTT)))**2
      IF(I-1)9,9,6
6     IF(I-JC)10,9,9
9     B(I,20)=.0
      B(I,21)=.0
      GO TO 11
10    CONTINUE
      B(I,20)=(1.-B(I,7)*B(I,6)/B(I,18)*B(I,5))*B(I,15)
      B(I,21)=(1.+B(I,7)*B(I,6)/B(I,18)/B(I,5))*B(I,17)
11    CONTINUE
      B(I,22)=B(I,20)*B(I,4)
10038 CONTINUE
       PP1=SIMPUN(B(1,3),B(1,16),JC)
       PP2=SIMPUN(B(1,3),B(1,15),JC)
       PP3=SIMPUN(B(1,3),B(1,17),JC)
      PP4=PP1/PP3
      PP5=PP2/PP3
       PP6=SIMPUN(B(1,3),B(1,22),JC)
       PP7=SIMPUN(B(1,3),B(1,20),JC)
       PP8=SIMPUN(B(1,3),B(1,21),JC)
      PP9=PP6/PP8
      PP10=PP7/PP8
      DO 10039 I=1,JC
      JCI=JC+1-I
      DO 10040 L=1,JC
      XO=B(L,3)-B(I,3)
      IF(XO) 860,860,871
860   XO=0.0
      GO TO 861
871   CONTINUE
      XO=B(L,3)-B(I,3)
861   CONTINUE
      B2(L)=XO*B(L,20)
10040 B3(L)=XO/B(L,3)*B(L,21)
      IF(JCI-2)10041,10041,10059
10041 B(I,25)=.0
      B(I,26)=.0
      B(I,27)=.0
      B(I,28)=.0
      GO TO 10039
10059 B(I,25)=SIMPUN(B(1,3),B(1,15),JC)*B(8,2)*B(3,2)**3*3.1415927*B(7,2
     1)**2 /(16.*B(9,2))
      B(I,26)=SIMPUN(B(1,3),B(1,16),JC)*B(8,2)*B(3,2)**2*B(7,2)**3/(16.*
     1 B(5,2)*B(9,2))
      BTI=ATAN(B(I,5))
      SBI=SIN(BTI)
```

```
      CBI=COS(BTI)
      B(I,27)=B(I,25)*CBI+B(I,26)*SBI
      B(I,28)=B(I,25)*SBI-B(I,26)*CBI
10039 CONTINUE
      DO 206 I=1,JC
      B(I,12)=B(I,4)*B(I,12)
      B(I,13)=B(I,4)*B(I,13)
206   B(I,14)=B(I,4)*B(I,14)
       IF(JEE.GT.0) GO TO 10081
      B15(181)=PP10
      DO 10049 I=1,JC
      IF(B(I,6)) 702,702,703
702   CC1=0.0
      GO TO 704
703   CC1=B(I,18)/B(I,6)
704   CONTINUE
      CL1(I)=CC1
      CC2=1.54*CC1
      CC3=.0679*CC1
      IF(CC1) 701,700,701
700   CC4=0.0
      B(I,38)=CC4
      GO TO 52
 701  CC4=B(I,7)/CC1
      B(I,38)=CC4
   52 CCONE(I)=CC1
      CCTWO(I)=CC2
      CCTHR(I)=CC3
10049 CCFOR(I)=CC4
10081 CONTINUE
20041 RETURN
      END
```

```
      SUBROUTINE SIMEQ(JC,C,CC)
C ---- NEW VERSION BY  JACK DISKIN -- X71450
      DIMENSION BA(12),C(12,12),CC(12,12)
      MPD=JC
      JCI=JC+1
      CC(JCI,1)=0.
      DO 80 I=1,JC
      C(I,JCI)=-CC(I,1)
      DO 78 J=2,JCI
78    CC(I,J)=0.
      CC(I,1)=-C(1,I+1)/C(1,1)
80    CC(I,I+1)=1.
      DO 89 K=2,JC
      DO 86 I=1,MPD
      BA(I)=0.
      DO 86 J=1,JCI
86    BA(I)= BA(I) + C(K,J)*CC(I,J)
      MPD=MPD-1
      DO 89 J=1,JCI
      Z=CC(1,J)/BA(1)
      DO 89 I=1,MPD
89    CC(I,J)=-BA(I+1)*Z + CC(I+1,J)
      DO 99 J=1,JCI
99    CC(J,1)=CC(1,J)
      RETURN
      END
```

```
      SUBROUTINE DISCOT (XA,ZA,TABX,TABY,TABZ,NC,NY,NZ,ANS)
      DIMENSION TABX(1),TABY(1),TABZ(1),NPX(37),NPY(37),YY(37)
C  MERGE OF DISCOT,DISSER,AND LAGRAN USING BUILT IN CONSTRAINTS
       NL=2
       IF(NC.EQ.-44) NL=3
      ID=2*NL-2
       NUPP=NY-NL
       DO 15 II=NL,NUPP
      NLOC=II
       IF( TABX(II).GE.XA)  GO TO 20
   15 CONTINUE
       NUPP=NUPP-NL+2
       GO TO 99
   20  NUPP=NLOC-NL+1
       NU=NUPP+ID
       DO 25 JJ=NUPP,NU
      NDIS=JJ
       IF( TABX(JJ) .EQ. TABX(JJ+1) ) GO TO 30
   25 CONTINUE
       GO TO 99
   30  NUPP=NDIS-ID
       IF(TABX(NDIS).LT.XA) NUPP=NDIS+1
   99 SUM=0.0
       NN=NUPP
       N=NN+ID
       DO 3 I=NN,N
       PROD=TABY(I)
       DO 2 J=NN,N
       A=TABX(I)-TABX(J)
       IF(A.EQ.0.) GO TO 2
       B=(XA- TABX(J) )/A
      PROD=PROD*B
    2 CONTINUE
    3 SUM=SUM+PROD
      ANS=SUM
      RETURN
      END
```

```
      SUBROUTINE STRESS(AZZ,AREA,XBAR,YBAR,AYEXO,AYEYO,EMXO,EMYO,EMTB,EM
     1OB,STRMAX,RAK,RAKOP)
      DIMENSION CHORD(11),THICKNS(11),CAMBER(11),PITCH(11),SKEWR(11)
     1,XI(11),BT(11)
      COMMON/CHEIGHT/XI,CHORD,THICKNS,CAMBER,PITCH,SKEWR,DIAM,ZZ,DEN
     1,RAKL,PI,PP7,PP8,PP9,PP11,EWAKE,VS,RPS,SIGMA,EAR,BT,P,PDO
     2  ,FWDDIAM,AFTDIAM,HUBLEN,FDBORE,ADBORE,DISREFL
       COMMON /UNITS/ SI,UI,UO
       DIMENSION RAK(11)
       DIMENSION AZZ(11,38)
      DIMENSION XE(20)
      DIMENSION HA(20),HA1(20),PHI(20),PHI2(20),XU1(20),T1(20),01(20),CP
     1HI(20),SPHI(20),X4(20),AE(20),BE(20),PE(20)
      DIMENSION   A(13),B(13),C(13),D(13),E(13),F(13),G(13),H(13),O(13),
     XP(13),Q(13),R(13),S(13),T(13),U(13),V(13),W(13),X(13),Y(13),Z(13)
      DIMENSION R1(7,16), S1(7,16)
      DIMENSION CENTST (7), CENTMO (7)
      DIMENSION FMX(7),TX(7),FMMX(13),YTX(13),SKEW(13),XU(10)
      DIMENSION VOL(7),CENT4(7),A1(7),A2(7),X2BAR(7),CENTS2(7),B2(13),
     X          F5(13),P2(13),02(13),AA(10),BB(10),CENT42(7),CENTMS(7),
     X          TSKEW1(7),TSKEW2(7),ASKEW1(7),ASKEW2(7)
      DIMENSION V2(13),D2(13),E2(13)
      DIMENSION  ALPHIA(7)
      DIMENSION XMT(10),XL(10),XM(10),XT(10),STM(10),STLT(10)
      DIMENSION AREA(7),XBAR(7),YBAR(7),AYEXO(7),AYEYO(7),EMXO(7),EMYO(7
     1),EMTB(7),EMOB(7),STRMAX(7)
       DATA AF,AT,ATX,ATF,ATFF,AFXX,ATTT,GRAV/1.40395,.72099,.341,.58032
     2 ,.50321,.41733,.12714,32.14 /
C
C * * * * * SIMPLE BEAM APPROXIMATION INCLUDING
C * * * * * BENDING, CENTRIFUGAL AND TORSIONAL FORCES.
       PI=3.1415926536
       ATXX=.202084
      NN=1
   18 FORMAT(8F9.6)
      ZZ=AZZ(9,2)
      VS=AZZ(7,2)
      DIAM=AZZ(3,2)
      DIA=DIAM
      VEL=60.0*AZZ(5,2)
      ISEC=0
      AZZ(10,20)=0.0
      AZZ(10,21)=BT(11)
      AZZ(10,22)=0.0
      DO 1000 I=1,10
      D(I)=AZZ(I,20)
      T(I)=AZZ(I,21)
      E(I)=AZZ(I,22)
      C(I)=AZZ(I,23)*DIA*12.0
      SKEW(I)=C(I)/2.0-AZZ(I,24)*DIA*12.0/2.0
 1000 XU(I)=AZZ(I,19)
      DO 30 J=2,7
   30 AZZ(J,25)=AZZ(J+1,25)
      DO 1001 I=1,7
       K=14-I
       J=K/13
       U(I)=.1*(I-2)+.05*J*(3-I)
```

```
      U(K)=1-U(I)
      TX(I)=AZZ(I,25)*DIA*12.0
      FMX(I)=.0679*DIA*AZZ(I,18)
      YBAR(I)=.0679*DIA*AZZ(I,18)
      FMX(I)=0.0
      A(I)=C(I)*TX(I)*AT
      X(I)=C(I)*ATX/AT
      Y(I)=FMX(I)*ATF/AT/2.
      G(I)=C(I)*TX(I)*(FMX(I)**2*ATFF+TX(I)**2*ATTT/3.)-A(I)*Y(I)*Y(I)
      H(I)=C(I)**3*TX(I)*ATXX - A(I)*X(I)*X(I)
 1001 CONTINUE
C  CALCULATE THE VALUE OF F1 FROM INPUT VALUES.
   26 F1=1.9905*(DIAM/2.0)**3*VS**2*PI*6.0/ZZ
      FF1=F1
      IF(PDO.GT.0.) GO TO 52
      DO 215 I=1,10
  215 P(I) = T(I)*PI*XU(I)
   52 NN=NN+1
C     ********************************** COMPUTE ***************************************
C  CALCULATIONS FOR CONSTANTS USED IN DETERMINATION OF TORQUE AND THRUST
C  CALCULATIONS OF BENDING MOMENTS FROM THRUST AND TORQUE.
      DO 360 I5=1,2
      F1=FF1
      RAD1=DIAM*0.5*12.0
      IF(I5-2)55,56,56
   55 DO 210 I=1,10
      PE(I)=P(I)
      AE(I)=D(I)*(1-E(I)*T(I))
      B(I)=D(I)*(E(I)+T(I))
      BE(I)=B(I)
      T(I)=P(I)/(PI*XU(I))
      PHI(I)=ATAN(T(I))
      CPHI(I)=COS(PHI(I))
      SPHI(I)=SIN(PHI(I))
      HA(I)=(SKEW(I))*(CPHI(I)/(RAD1*XU(I)))
      XU1(I)=XU(I)*COS(HA(I))
      HA1(I)=C(I)/2.
  210 IF(SKEW(I).EQ.HA1(I)) XU1(I)=XU(I)
      GO TO 58
   56 DO 57 I=1,10
      P(I)=PE(I)
   57 B(I)=BE(I)
   58 F1=F1/60.0
      DO 69 I=1,7
      I1=I
      IF(I5-2)62,63,63
   62 XO=XU1(I)
      GO TO 64
   63 XO=XU(I)
   64 I3=0
      DO 68 I2=I1,10
      I3=I3+1
      IF(I5-2)65,66,66
   65 X4(I3)=(XU1(I2)-XO)
      XE(I3)=XU(I2)
      GO TO 67
   66 X4(I3)=(XU(I2)-XO)
```

```
      XE(I3)=XU(I2)
   67 T1(I3)=X4(I3)*AE(I2)
   68 Q1(I3)=X4(I3)*B(I2)
      T(I)=SIMPUN(XE,T1,I3)
      Q(I)=SIMPUN(XE,Q1,I3)
      T(I)=T(I)*FF1
   69 Q(I)=Q(I)*FF1
C
C  LOOP WHICH APPROXIMATES STRESS DUE TO TORSION RESULTING
C    FROM SKEW
C     XT(I) = LIFT FORCE ,  XMT(I) = MOMENT DUE TO LIFT
C
      DO 111 I=1,7
      IF(I5-2)820,830,830
  820 XMT(I)=0.00
      XK=1.9905*(DIAM/2.0)**2.*VS**2.*PI/(2.0*77)
      XA=C(I)/2.0
      XB=TX(I)/2.0
      DO 222 J=I,9
      XL(J)=ABS(SKEW(J)-.45*C(J))
      XL(J)=XL(J)-ABS(SKEW(I)-.5*C(I))
       XT(J)=AE(J)*.1*XK/(COS(PHI(J)+E(J)))
      XM(J)=XT(J)*XL(J)
      XMT(I)=XMT(I)+XM(J)
  222 CONTINUE
      STM(I)=XMT(I)*2.0/(PI*XA*XB**2.)
      STLT(I)=XMT(I)*2.0/(PI*XB*XA**2.0)
      GO TO 840
  830 STM(I)=0.00
      STLT(I)=0.00
840   CONTINUE
  111 CONTINUE
  550 FORMAT(1H0,29X,1HX,10X,4HTAUM,12X,5HTAULE,10X,7HM SUB T)
  500 FORMAT(1H,20X,4F18.6)
  600 FORMAT(1H1,50X,32HSHEARING STRESSES DUE TO TORSION)
C
C
C  LOOP WHICH CALCULATES VOL. OF SECTIONS.
      VOLTOT=0.0
      DO 241 I=1,6
       VOL(I)=A(I)*(XU(I+1)-XU(I))*DIAM/288.
  241 VOLTOT=VOLTOT+VOL(I)
       VOL(7)=A(7)*(1-XU(7))*DIAM/576.
  243 VOLTOT=VOLTOT+VOL(7)
C  LOOP WHICH CALCULATES CENTRIFUGAL FORCE AND STRESS.
      IF(I5-2)244,246,246
  244 DO 245 I=1,6
  245 A1(I)=XU1(I)+((XU1(I+1)-XU1(I))/2.0)
      A1(7)=XU1(7)+((XU1(10)-XU1(7))/2.0)
      GO TO 248
  246 DO 247 I=1,6
  247 A1(I)=XU(I)+((XU(I+1)-XU(I))/2.0)
      A1(7)=XU(7)+((XU(10)-XU(7))/2.0)
C  LOOP TO TRANSFER CONSTANTS FOR DETERMINING X2BAR.
  248 DO 236 I=1,7
      X2BAR(I) = 0.0
  236 A2(I) = A1(I) * VOL(I)
```

```
C  LOOP TO CALCULATE RADIAL CENTROID ( X2BAR ).
      DO 251 I=1,7
      X2BAR(I) =( (A2(1)+A2(2)+A2(3)+A2(4)+A2(5)+A2(6)+A2(7)) / VOLTOT )
     X             * (DIAM/2.0)
      A2(I) = 0.0
C  UNCORRECTED FORCE AND STRESS FOR OUTPUT OF ANSWERS WITHOUT THE EFFECT
C  RAKE AND SKEW TAKEN INTO CONSIDERATION.
  264 CENT4(I) = DEN*4.0*PI**2*VEL**2*VOLTOT*X2BAR(I)/(3600.0*GRAV)
      CENTST(I) = CENT4(I) / A(I)
  251 VOLTOT = VOLTOT - VOL(I)
C  LOOKING AT THE EFFECTS OF RAKE AND SKEW IN THE PROPELLER.
      DO 263 I=1,10
       AA(I)=PI*XU(I)
  263 BB(I) = SQRT(AA(I)**2+P(I)**2)
      DO 267 I=1,7
      TSKEW1(I) = (C(I)/2.0 - SKEW(I)) * AA(I)/BB(I)
      KK = 1
  146 IF(X2BAR(I)-XU(KK) *DIAM/2.0) 149,149,151
  151 KK= KK+1
      IF(KK-10)146,149,149
  149 TSKEW2(I) = (C(KK)/2.0 - SKEW(KK)) * AA(KK)/BB(KK)
      ALPHIA(I)=ATAN(TSKEW2(I)/(X2BAR(I) * 12.0) )
      CENT42(I) = CENT4(I)*COS(ALPHIA(I))
      CENTMS(I) = CENT42(I)*(TSKEW2(I) - TSKEW1(I))
      CENTS2(I) = CENT42(I) / A(I)
      ASKEW1(I)=(TSKEW1(I)*P(I)/AA(I)) + RAK(I)
      ASKEW2(I)=(TSKEW2(I)*P(I)/AA(I)) + RAK(KK)
   77 CONTINUE
  267 CENTMO(I) = CENT42(I) * ( ASKEW2(I) - ASKEW1(I) )
      DO 281 I=1,7
      D(I) = ((T(I)+CENTMO(I))*AA(I)+(Q(I)-CENTMS(I))*P(I))/BB(I)
      E(I)=((T(I)+CENTMO(I))*P(I)-(Q(I)-CENTMS(I))*AA(I))/BB(I)
      D2(I)=(T(I)*AA(I)+Q(I)*P(I)) / BB(I)
  281 E2(I)=(T(I)*P(I)-Q(I)*AA(I)) / BB(I)
C  PROGRAM CONTINUES.
      DO 350 I=1,7
       K=1
       S(1)=0
       Z(K)=U(7)
       F2=FMX(I)+.4962*TX(I)-Y(I)
      DO 300 L=1,K
      B(L)=((C(I)*Z(L)-X(I))*E(I))/H(I)+F2*D(I)/G(I)+CENTS2(I)
      B2(L)=((C(I)*Z(L)-X(I))*E2(I))/H(I)+F2*D2(I)/G(I)+CENTST(I)
      V2(L) = ABS(B2(L))
  300 V(L)=ABS(B(L))
      F3=V(1)
      F4 = V2(1)
      F(I)=B(1)
      F5(I) = B2(1)
      DO 320 L=1,K
      F(I)=V(L)
  320 F5(I)=V2(L)
      F5(I) = 0.0
  340 P(I)=-X(I)*E(I)/H(I)-(C(I)*S(1)-Y(I))*D(I)/G(I)+CENTS2 (I)
      P2(I)=-X(I)*E2(I)/H(I)-(C(I)*S(1)-Y(I))*D2(I)/G(I)+CENTST(I)
      O2(I)=(C(I)-X(I))*E2(I)/H(I)-(-Y(I))*D2(I)/G(I)+CENTST(I)
  350 O(I)=(C(I)-X(I))*E(I)/H(I)-(-Y(I))*D(I)/G(I)+CENTS2 (I)
```

```
      DO 100 I=1,7
      AREA(I)=A(I)
      XBAR(I)=X(I)
      AYEXO(I)=G(I)
      EMXO(I)=D(I)
      AYEYO(I)=H(I)
      EMYO(I)=E(I)
      STRMAX(I)=AZZ(I,11)
      EMTB(I)=T(I)
  100 EMOB(I)=Q(I)
      IF(IS-2) 351,352,352
351   CONTINUE
      CALL PRNSTR (F,P,O,STM,STLT,AZZ)
C     ********************************** PRINT OUTPUT ************************************
      GO TO 360
  352 DUMMY=DUMMY
      NN = NN+1
  360 NN=NN+1
      RETURN
       END
```

```
      SUBROUTINE PRNSTR (XX,YY,ZZ,S1,S2,AZZ)
       DIMENSION AZZ(11,38)
      DIMENSION XX(10),YY(10),ZZ(10),S1(10),S2(10)
C
C     CALCULATION OF PRINCIPLE STRESSES
C     DUE TO TORSION AND BENDING.
C
      DIMENSION XI2(10),XI3(10)
      DO 333 K=1,7
      XI2(K)=-S1(K)*S1(K)
      XI3(K)=-S2(K)*S2(K)
  333 CONTINUE
      XXX=0.1
      DO 444 L=1,7
      XXX=XXX+0.1
      DO 555 M=1,3
      IF(M-2)72,22,33
   72 XI1=XX(L)
      DD=(ABS(XI1))**2.0
      XD=DD-4.*XI2(L)
      CC=(ABS(XD))**.5
      GO TO 44
   22 XI1=YY(L)
      GO TO 66
   33 XI1=ZZ(L)
   66 DD=(ABS(XI1))**2.0
      XD=DD-4.*XI3(L)
      CC=(ABS(XD))**.5
   44 SIGMA1=(XI1+CC)/2.0
      SIGMA2=(XI1-CC)/2.0
      AZZ(L,M)=XXX
      AZZ(L,M+10)=SIGMA1
555   AZZ(L,M+20)=SIGMA2
  444 CONTINUE
  700 FORMAT(1H,20X,F12.2,6X,2E20.6)
  850 FORMAT(1H0,33X,1HX,12X,6HSIGMA1,10X,6HSIGMA2)
  860 FORMAT(1H0,2X,99HSTRESSES AT EACH X STATION ARE GIVEN IN THE FOLLO
     XWING ORDER* MIDCHORD, LEADING EDGE, TRAILING EDGE. )
      RETURN
      END
```

```
      FUNCTION SIMPUN(X,Y,N)
C     FORTRAN IV FUNCTION FOR SIMPSONS RULE INTEGRATION
C      ARBITRARY NO. AND LENGTH INTERVALS K.MEALS NSRDC CODE 842 10-5-67
      DIMENSION X(2),Y(2)
      IF(N-2) 7, 5,4
    5 S=(Y(1)+Y(2))*(X(2)-X(1))/2.
      GO TO 6
    4 M=N-1
    8 IF(M-2) 9,10,11
   11 M=M-2
      GO TO 8
    9 S=(X(2)-X(1))/6.*(Y(1)*(3.-(X(2)-X(1))/(X(3)-X(1)))+Y(2)*(3.+(X(2)
     1-X(1))/(X(3)-X(2)))-Y(3)*(((X(2)-X(1))**2)/((X(3)-X(1))*(X(3)-X(2)
     2))))
      L=3
      GO TO 12
   10 S=0.
      L=2
   12 M=N-1
      DO 1 K=L,M,2
      IF(ABS(X(K-1)-X(1)).GE.ABS(X(K)-X(1))) GO TO 3
      IF(ABS(X(K+1)-X(1)).GT.ABS(X(K)-X(1))) GO TO 1
    3  WRITE(6,2) K,X(K-1),Y(K-1),X(K),Y(K),N
    2  FORMAT(* NON MONOTONE X(SIMPUN)*,I4,2X,1P2E12.4,5X,2E12.4,5X,I4)
    7 S=0.
      GO TO 6
    1 S=S+(X(K+1)-X(K-1))/6.*(Y(K-1)*(3.-(X(K+1)-X(K-1))/(X(K)-X(K-1)))+
     1(Y(K)*(1.+(X(K+1)-X(K-1))/(X(K)-X(K-1))+(X(K)-X(K-1))/(X(K+1)-X(K)
     1))+(Y(K+1)*(2.-(X(K)-X(K-1))/(X(K+1)-X(K))))))
    6 SIMPUN=S
      RETURN
      END
```

```
      SUBROUTINE WEIGHT(JC,SIGMA7,HUB,PMHC,WEIGHTB,WEIGHTH,RAK)
C        WEIGHT COMPUTES THE WEIGHT AND CENTER OF GRAVITY.  THE VALUES F
C        CHORD, THICKNS, CAMBER, PITCH AND SKEWP COME FROM GMAIN.  DIAM,
C        DEN, RAKE AND PI ARE SET IN STRESS.  OTHER VALUES ARE COMPUTED
C        MAKING CERTAIN ASSUMPTIONS.
C        THE ARRAY RAK USED FOR RAKE COME FROM GMAIN
       DIMENSION P(13),BT(11),RAK(11)
       COMMON /UNITS/ SI,UI,UO
      COMMON/CWEIGHT/X,CHORD,THICKNS,CAMBER,PITCH,SKEWP,DIAM,ZZ,DEN,RAKE
     1,PI,CTS,CPS,EP,PC,WAKE,VS,RPS,SIGMA,EAR ,BT,P,PDO
     2  ,FWDDIAM,AFTDIAM,HUBLEN,FDBORE,ADBORE,DISREFL
      DIMENSION CHORD(11),THICKNS(11),CAMBER(11),PITCH(11),SKEWP(11)
     1,X(11)
      DIMENSION DISTHF(38),A(38)
      DIMENSION R(9),PMT(9)
      DATA CNSTNT1,CNSTNT2,CNSTNT3/.3605,.8071,.0239/
       DATA THB1,THB2,THB3,THB4   /6H CYLIN,6HDRICAL,6H  DESI,6HGNATED/
       DATA UFE,UFS / 5H(LBF) ,5H(N)    /
       DATA UEI,UEF,USL /4H(IN) ,4H(FT) , 4H(M)  /
C        ****VALUES COMPUTED AND DATA OUTPUT****
C        THE HUB DIAMETER IS ASSUMED TO BE THE DIAMETER TO THE FIRST RAD
C        RATIO TO BE CONSIDERED AND THE HUB ASSUMED TO BE CYLINDRICAL.
C        THE HUB LENGTH IS ASSUMED TO EQUAL THE HUB DIAMETER AND THE DIS
C        THE REFERENCE LINE FROM THE HUB FACE IS TAKEN AS HALF THE HUB L
C        INPUT DATA AND ASSUMED DATA WRITTEN OUT.
       CGR(X,Y,H)=H*(X*X+2*X*Y+3*Y*Y)/(X*X+X*Y+Y*Y)/4.
       VOL(X,Y,H)=H*(X*X+X*Y+Y*Y)/3.
       PMFR(X,Y)=X*X*X*X+X*X*X*Y+X*X*Y*Y+X*Y*Y*Y+Y*Y*Y*Y
       ATH=THB1
       BTH=THB2
       IF(HUB.NE.0.) ATH=THB3
       IF(HUB.NE.0.) BTH=THB4
      HUBDIAM=X(1)*DIAM
       IF(HUB.NE.0.) GO TO 50
      DISREFL=HUBDIAM/2.
      HUBLEN=HUBDIAM
      CENGRVH=HUBLEN/2.
      GO TO 270
   50 FWDRAD=FWDDIAM/2.0
      AFTRAD=AFTDIAM/2.0
      HUBRAD=HUBDIAM/2.0
      FRBORE=FDBORE/2.
      ARBORE=ADBORE/2.
C        ****WEIGHT CALCULATION****
  270 DO 10 I=1,JC
   10 A(I)=CHORD(I)*THICKNS(I)
C        WEIGHT OF THE BLADES
      BSA1=SIMPUN(X,A,JC)
      WEIGHTB=CNSTNT1*DIAM*DEN*ZZ*BSA1
C        WEIGHT OF THE HUB
      IF(HUB.EQ.0.) GO TO 200
  201  HRBORE=ARBORE+DISREFL*(FRBORE-ARBORE)/HUBLEN
```

```
      WS1=PI*DEN*VOL(AFTRAD,HUBRAD,DISREFL)
      WB1=PI*DEN*VOL(ARBORE,HRBORE,DISREFL)
      WFR1=WS1-WB1
      IF(HRBORE.EQ.ARBORE) HRBORE=ARBORE+.00000001
      AFM=WS1*CGR(AFTRAD,HUBRAD,DISREFL)-WB1*CGR(ARBOPE,HRBCRE,DISPEFL)
      DS=HUBLEN-DISREFL
      WS2=PI*DEN*VOL(HUBRAD,FWDRAD,DS)
      WB2=PI*DEN*VOL(HRBORE,FRBORE,DS)
      WFR2=WS2-WB2
      FWM=DISREFL*WFR2+WS2*CGR(HUBRAD,FWDRAD,DS)
      IF(FRBORE.EQ.HRBORE) FRBORE=HRBORE+.00000001
      FWM=FWM-WB2*CGR(HRBORE,FRBORE,DS)
      WEIGHTH=WFR1+WFR2
      CENGRVH=(AFM+FWM)/WEIGHTH
      GO TO 202
  200 WEIGHTH=PI*HUBDIAM**2*HUBLEN*DEN/4.
  202 CONTINUE
C        WEIGHT OF THE PROPELLER
      WEIGHTP=WEIGHTB+WEIGHTH

C        ****CENTER OF GRAVITY CALCULATION****
      DO 20 I=1,JC
   20 DISTHF(I)=CNSTNT2*CAMBER(I)*COS(PITCH(I))+CNSTNT3*CHORD(I)
     1*SIN(PITCH(I))+DISREFL

C        THE EFFECT OF RAKE AND SKEW ARE ADDED TO THE DISTANCE OF THE CE
C        GRAVITY FROM THE HUB FACE FOR EACH SECTION.
      DO 30 I=1,JC
      DISTHF(I)=DISTHF(I)-SKEWR(I)*X(I)/2.*DIAM*TAN(PITCH(I))-RAK(I)/12.
   30 A(I)=CHORD(I)*THICKNS(I)*DISTHF(I)
      BSA2=SIMPUN(X,A,JC)
      CENGRV3=BSA2/BSA1
      CENGRVB=DISREFL-CENGRV3
C        CENTER OF GRAVITY CONSIDERING RAKE AND SKEW
      CENGRV1=(WEIGHTB*CENGRV3+WEIGHTH*CENGRVH)/WEIGHTP
      CENGRVF=DISREFL-CENGRV1

      IF(HUB.EQ.0.) GO TO 250
       CP=PI*DEN*14.4
       PMA=DISREFL*PMFR(HUBRAD,AFTRAD)
       PMF=DS*PMFR(FWDRAD,HUBRAD)
       PMB=HUBLEN*PMFR(FRBORE,ARBORE)
       PMHC= CP*(PMA+PMF-PMB)
      GO TO 251
  250  PMHC=WEIGHTH*HUBRAD**2*72
  251 CONTINUE
C        ****RESULTS OUTPUT****
       SLF=.3048
       UB=WEIGHTB
       UP=WEIGHTP
       CFL=CENGRVF/DIAM
       CBL=CENGRVB/DIAM
       BA=HUBLEN/DIAM
       BB=FWDDIAM/DIAM
       BC=AFTDIAM/DIAM
       BD=DISREFL/DIAM
       BE=HUBDIAM/DIAM
```

```
      BF=FDBORE/DIAM
      BG=ADBORE/DIAM
      SW=UFE
      IF(UO.NE.SI) GO TO 531
      SW=UFS
      UP=UB*4.448222
      UF=UP*4.448222
  531 PRINT 104,SW,UB,ATH,BTH,SW,UP,   CFL,   CRL
      IF(HUP.EQ.0.) GO TO 55
      PRINT 108,    BA,BB,BC,BD,BE,BF,BG
      GO TO 53
   55 CONTINUE
      PRINT 110,    BE,BA,BD
   53 CONTINUE

C         MINIMUM EXPANDED AREA RATIO CALCULATIONS
      AJS=VS/(RPS*DIAM)
      AJA=WAKE*AJS
      AKT=PI*CTS*AJS**2/8.
      AKO=CPS*AJS**3/16.
      EARMIN=(2.6+0.6*ZZ)*AKT/(SIGMA7*(AJA**2+(.7*PI)**2))+.15
      PRINT 105,EARMIN,AJS,AJA,AKT,AKO,   PC


  104 FORMAT(  //20X,*WEIGHT OF BLADES*  ,A5,*=*,F15.4//20X,*WEIGHT OF P
     1ROP (BLADES +*2A6,* HUB)*     ,A5,*=*     ,F15.4//20X,*CENTER OF GRA
     2VITY OF PROP REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AF
     3T)/D=*     ,F9.6//20X,*CENTER OF GRAVITY OF BLADES REFERENCED FROM
     4 MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D=*     ,F9.6)
  105 FORMAT(/20X,*KELLERS MINIMUM EAR=*,E10.4
     1//20X,*SPEED COEFF   V/(ND)     JS=*,E10.4//20X,*ADVANCE COEFF    V(
     21-WTT)/(ND)    JA=*,E10.4//20X,*DESIGN THRUST COEFF     KT=*,E
     310.4//20X,*TORQUE COEFF     KQ=*,E10.4//
     4  20X,*PROPULSIVE EFFICIENCY  ETAD=*,E10.4)
  110 FORMAT(/20X,*HUB DIMENSIONS/D*, 8X ,*   HUB DIAM =*F9.4/47X,*HUB L
     1ENGTH =*,F9.4/47X,*MIDCHORD OF ROOT SECTION TO AFT END OF HUB =*,F
     29.4)
  100 FORMAT(6F8.4)
  107 FORMAT(  //20X,*WEIGHT OF BLADES* ,A5,*=*, F15.4//20X,*WEIGHT OF P
     1ROP (BLADES + TAPERED HUB)* ,A5,*=*,F15.4     //20X,*CENTER OF GRA
     2VITY OF PROP REFERENCED FROM MIDCHORD OF ROOT SECTION (- FWD, + AF
     3T)/D=*     ,F9.4//20X,*CENTER OF GRAVITY OF BLADES REFERENCED FROM
     4 MIDCHORD OF ROOT SECTION (- FWD, + AFT)/D=*     ,F9.4)
  108 FORMAT(/20X,*HUB DIMENSIONS/D*    ,11X,*LENGTH=*,F9.4/47X,*FWD DIA
     1M=*,F9.4/47X,*AFT DIAM=*,F9.4/47X,*MIDCHORD OF ROOT SECTION TO AFT
     2 END OF HUB=*,F9.4/47X,*HUB DIAM AT MIDCHORD OF ROOT SECTION=*,F9.
     34/47X,*FWD DIAM OF BORE=*,F9.4/47X,*AFT DIAM OF BORE=*,F9.4)
      RETURN
      END
```

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